

TECHNICAL REPORT

Inverter Altitude Derating and Usage Restrictions

Subject: Explanation of Power Derating for IP65 Models and Usage Prohibition for IP20 Models at High Altitudes (>6561.68 ft. or >2000 m).

Date: March 6, 2026

1. EXECUTIVE SUMMARY

EG4 understands several installations in the United States are located at high altitudes (e.g. 7800 ft, 8000 ft, 8500 ft+ or 2400 m – 2600 m). To ensure long-term system reliability and safety, we have conducted a thorough engineering assessment based on our inverters' specific thermal designs and protection ratings.

This report details the technical rationale behind two distinct policies:

1. **IP65 Models:** Allowed for use with mandatory power derating.
2. **IP20 Models:** Strictly prohibited for use above 6561.68 ft. (2000 m).

These decisions are driven by the fundamental differences in cooling airflow paths and environmental protection capabilities between the two form factors.

2. THE THREE PHYSICAL CHALLENGES OF HIGH ALTITUDE

Before analyzing the specific models, it is crucial to understand how high altitude affects electronic equipment:

1. **Reduced Air Density (Thermal Challenge):** Air density decreases by approximately 10 – 12% for every ~3281 ft. (1000 m) of elevation. Since convective heat transfer is directly proportional to air mass flow, cooling efficiency drops significantly. At 9842.52 ft. (3000 m), the air's capacity to remove heat is ~70% of its sea-level capability.
2. **Reduced Dielectric Strength (Electrical Risk):** According to Paschen's Law, lower atmospheric pressure reduces the breakdown voltage of air. Electrical clearances that are safe at sea level may experience arcing or flashover at high altitudes.
3. **Condensation and Contamination (Environmental Risk):** High-altitude regions often experience large diurnal temperature swings, leading to condensation. Combined with potential dust, this creates a harsh environment for exposed electronics.

3. IP65 MODELS: WHY “DERATING” IS THE SOLUTION

3.1 THERMAL ARCHITECTURE: EXTERNAL FIN COOLING

- **Design:** IP65 units feature a fully sealed enclosure. The cooling fan directs airflow specifically onto an external aluminum heatsink located at the rear of the unit. Heat is conducted from internal components to the fins and then dissipated by the airflow.
- **High Altitude Impact:**
 - Due to thin air, the convective heat transfer coefficient of the heatsink drops.
 - Consequence: If operated at full rated power, the junction temperature of power devices (IGBTs/MOSFETs) would exceed safe limits (typically 125°C or 150°C).
- **The Solution – Derating:**
 - By reducing the output power, we directly reduce the heat generation.
 - The balance: Our derating curve
 - 0.85 for 6562 ft. – 9842.52 ft. (2000 m – 3000 m)
 - 0.7 for 9843 ft. – 13123.36 ft. (3000 m – 4000 m)

3.2 ENGINEERING VALIDATION OF DERATING COEFFICIENTS

Our proposed derating curve is a calculated engineering compromise based on the thermal physics of air density at altitude and the lifetime degradation of models of our key components (specifically electrolytic capacitors and power modules). This ensures that even at 8500 ft., the internal temperature rise remains within the same safe margins as sea-level operation, guaranteeing the design life.

Altitude Range	Air Density (approx.)	Cooling Capacity Loss	Required Power Limit	Engineering Rationale
0 – 6561.68 ft. (0 – 2000 m)	100%	None	100%	Standard operation.
6561.68 – 9842.52 ft. (2000 – 3000 m)	~80%	~18 – 20%	85%	Reducing power to 85% lowers heat generation sufficiently to offset the ~20% loss in cooling efficiency, maintaining component temperatures within safe margins.
9842.52 – 13123.36 ft. (3000 – 4000 m)	~70%	~30 – 35%	70%	At this elevation, a 30% power reduction is critical to prevent thermal runaway and to compensate for reduced fan mass-flow efficiency.
>13123.36 ft. >4000 m	<60%	>40%	Not allowed	Exceeds the thermal and insulation design limits of the platform.

Key benefits of this strategy:

- **Capacitor Lifetime:** Lowering the operating temperature by derating counteracts the accelerated aging of electrolytic capacitors caused by low atmospheric pressure.
- **Safety Margin:** This curve ensures that even at 8500 ft., the internal temperature rise remains within the same safety margins as sea-level operation, guaranteeing the designed 20+ year service life.

NOTE

Regarding ambient temperature: These derating factors assume an ambient temperature of $\geq 104^{\circ}\text{F}$ (40°C). If the installation site experiences summer temperatures $> 104^{\circ}\text{F}$ (40°C), additional derating or enhanced shading/ventilation is required. For example, high-altitude areas in the western United States, such as the Rocky Mountains, have strong summer sunlight. If the inverter is installed in direct sunlight, the ambient temperature may reach 113°F (45°C) or higher.

4. IP20 MODELS: WHY “PROHIBITION” IS MANDATORY

4.1 THERMAL ARCHITECTURE: INTERNAL DIRECT BLOWING

- **Design:** IP20 units utilize an open-chassis design where the fan blows ambient air directly over the internal PCBA, capacitors, and inductors.
- **Critical High-Altitude Risks:**
 - **Risk A: Thermal Failure & Hotspots.** While the fan spins, the thin air cannot effectively remove heat from densely packed components. More critically, complex internal airflow can create localized “hot spots” on chip backs or under capacitors, leading to irreversible damage.
 - **Risk B: Direct Condensation Ingestion.** Condensation formed during cold nights is sucked directly into the chassis by the fan and deposits onto live circuits. This causes immediate short circuits, corrosion, or LCD driver failures.
 - **Risk C: Conductive Dust & Arcing.** Dust particles are blown directly onto high-voltage nodes. Under low pressure conditions (reduced insulation) combined with moisture-absorbing dust, the risk of high-voltage arcing and fire increases exponentially.

4.2 WHY DERATING IS NOT ENOUGH FOR IP20

- Derating solves the heat problem, but it does not solve the insulation or contamination problems.
- Even at low power, as long as the fan operates, it pumps moist, dusty, low-pressure air onto the circuit board. A single flashover event can destroy the unit instantly.
- **Conclusion:** The physical structure of IP20 units cannot mitigate the environmental erosion and insulation degradation inherent to high altitudes. **Derating cannot eliminate these physical risks. Therefore, usage must be prohibited.**

5. MANDATORY IMPLEMENTATION PROCEDURE

To ensure warranty validity and system safety, the modification of rated power settings is not a field-configurable action for end-users without oversight.

- Step-by-Step Protocol:
 - **Site assessment:** Confirm the exact altitude of the installation site (in feet or meters).
 - **Model Verification:** Ensure the installed hardware is an IP65 rated model. (If IP20, replacement is mandatory).
 - **Formal Request:** The installer/end-user must contact their authorized Distributor (or the Manufacturer’s) Technical Support team with the site details.
 - **Engineering Review:** Our engineering team will review the specific site conditions (altitude, ambient temperature profile) and confirm the appropriate derating factor (0.85 or 0.7).
 - **Authorized Configuration:**
 - Upon approval, the Distributor or Manufacturer will remote configuration service to adjust the power limit.
 - Do not attempt to bypass these limits manually. Unauthorized modifications will void the product warranty and may create safety hazards.
 - **Confirmation:** A formal confirmation email or document stating the new rated power must be archived for project records.



WARNING

Operation of IP65 inverters above 6561.68 ft. (2000 m) without authorized derating, or any operation of IP20 inverters above 6561.68 ft. (2000 m), constitutes misuse. Any resulting equipment failure, fire, or safety incident will not be covered under warranty.

6. SUMMARY COMPARISON

Feature	IP65 Model (Derating Allowing)	IP20 Model (Usage Prohibited)
Cooling Method	Fan blows on external heatsink (indirect)	Fan blows directly on internal PCBA (direct)
Primary Bottleneck	Reduced heatsink efficiency due to thin air	Thin air + insulation failure + contaminant ingress
Impact of Condensation/Dust	None (fully sealed isolation)	Fatal (Directly ingested onto live circuits)
Low-Pressure Insulation Risk	Low (Internal conformal coating/potting)	High (Open layout, clearances prone to arcing)
Mitigation Strategy	Derating: Reduce heat to match cooling capacity.	Prohibition: Physical design cannot prevent environmental damage
Max Allowed Altitude	≤ 13123.36 ft. (4000 m)	≤ 6561.68 (2000 m)

7. RECOMMENDATIONS FOR YOUR PROJECTS

For your sites located at 7800 ft. (~2377 m), 8000 ft. (~2438 m), and 8500 ft. (~2590 m):

- Model Verification:** Ensure **only IP65** rated inverters are deployed. If IP20 units are currently installed or planned for these elevations, **usage must be discontinued immediately**. Operating IP20 units here poses an extreme risk of failure and safety hazards, and such damage will not be covered under warranty.
- Power Configuration:** For IP65 units, configure the maximum power limit based on the specific altitude:

Device Type	Altitude (Meters)	Power Rating limitation	Max. charge/discharge power limitation	Max. On-grid Power Limitation	Max. EPS Output	Power Rating Setting
12kPV	0 – 6561.68 ft. (0 – 2000 m)	8kW (Default)	8kW	8kW	8kW	8kW
	6561.68 – 9842.52 ft. (2000 – 3000 m)	5kW	5kW	5kW	5kW	5kW
	9842.52 – 13123.36 ft. (3000 – 4000 m)	5kW	5kW	5kW	5kW	5kW
	>13123.36 ft. (>4000 m) Not Allowed	-	-	-	-	-
18kPV	0 – 6561.68 ft. (0 – 2000 m)	12kW (Default)	12kW	12kW	12kW	12kW
	6561.68 – 9842.52 ft. (2000 – 3000 m)	10kW	10kW	10kW	10kW	10kW
	9842.52 – 13123.36 ft. (3000 – 4000 m)	8kW	8kW	8kW	8kW	8kW
	>13123.36 ft. (>4000 m) Not Allowed	-	-	-	-	-
FlexBOSS18	0 – 6561.68 ft. (0 – 2000 m)	13kW (Default)	10kW	13kW	8kW	13kW
	6561.68 – 9842.52 ft. (2000 – 3000 m)	8kW	8kW	8kW	8kW	8kW
	9842.52 – 13123.36 ft. (3000 – 4000 m)	5kW	5kW	5kW	5kW	5kW
	>13123.36 ft. (>4000 m) Not Allowed	-	-	-	-	-
FlexBOSS21	0 – 6561.68 ft. (0 – 2000 m)	16kW (Default)	12kW	16kW	12kW	16kW
	6561.68 – 9842.52 ft. (2000 – 3000 m)	10kW	10kW	10kW	10kW	10kW
	9842.52 – 13123.36 ft. (3000 – 4000 m)	8kW	8kW	8kW	8kW	8kW
	>13123.36 ft. (>4000 m) Not Allowed	-	-	-	-	-

- Monitoring:** We need to notice “Over-Temperature” alarm in the monitoring platform to track operating, especially during extreme weather events.

TECHNICAL DISCLAIMER

These specifications are based on IEC 62109 and UL 1741 standards, combined with our specific product thermal architecture. Equipment damage resulting from violation of these guidelines (e.g., using IP20 above 9842.52 ft. (2000 m) or running IP65 at full load above 9842.52 ft. (2000 m)).

Should you require further clarification or assistance with configuration, please contact our technical support team at support@eg4electronics.com.

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