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SOFT-START VS. HARD-START IN HVAC/R

WHAT THEY ARE, WHY THEY EXIST, & WHEN TO USE THEM

USA INNOVATION

Executive Summary:
As modern HVAC systems evolve, contractors and homeowners are increasingly challenged to manage electrical demand, startup reliability, and equipment longevity. Compressor startup, in particular, represents one of the most demanding moments in system operation[2]—placing stress on both electrical infrastructure and mechanical components[2].

Two widely used solutions—hard start kits and soft start devices—address these challenges in different ways. While often grouped together, they are not interchangeable. Hard start kits provide a temporary boost in starting torque to overcome difficult mechanical conditions, whereas soft start devices reduce inrush current and smooth electrical demand during startup.

This paper explores how each technology works, where it is best applied, and how contractors can make informed decisions to improve system performance, reduce failures, and enhance the overall user experience.

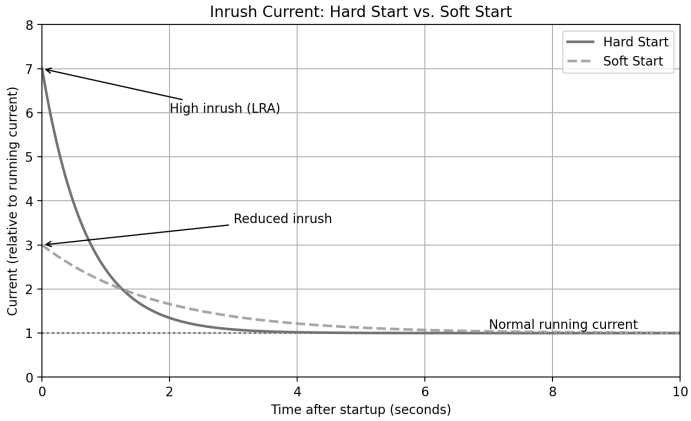
Growing Importance of Startup Management
Today's HVAC installations are increasingly deployed in environments with electrical constraints, including generator-backed homes, inverter systems, and aging residential infrastructure. At the same time, homeowners expect quieter operation, improved reliability, and longer equipment life.

These trends make compressor startup management more critical than ever. Poor startup performance can lead to nuisance breaker trips, voltage drops, increased wear on components, and premature system failure. Selecting the appropriate start-assist technology is no longer optional—it is essential to system performance and customer satisfaction.

Understanding Motor Startup
Compressor startup is the most electrically and mechanically stressful moment in an HVAC system's operation. At startup, the motor is stationary and must overcome inertia and system pressure simultaneously. During this brief moment, it draws locked rotor amperage (LRA), which can be five to ten times higher than normal running current[4, 10].

Mechanically, startup introduces torque shock and rapid heat buildup as the compressor accelerates against refrigerant pressure[4]. Repeated hard starts can degrade internal components such as bearings, windings, and valves, ultimately reducing system lifespan and increasing maintenance costs[2].

Effectively managing startup conditions is therefore critical to ensuring electrical stability, protecting mechanical components, and maintaining long-term system reliability.



Two Different Problems, Two Different Solutions
Although often discussed together, hard start kits and soft start devices are designed to solve fundamentally different problems.

Hard start kits address insufficient starting torque. They help compressors overcome difficult conditions such as high head pressure, low voltage, or mechanical wear.

Soft start devices address excessive electrical demand. They reduce inrush current and smooth the application of power, minimizing electrical disturbances and system stress.

Understanding this distinction is key: one solution helps the compressor start, while the other helps the electrical system handle the start.

Hard Start Technology: Torque Boost for Difficult Starts
Hard start kits were developed to ensure reliable compressor startup under real-world conditions where ideal voltage and pressure are not always present.

In standard operation, a compressor relies on its run capacitor and line voltage to initiate motion. However, conditions such as high ambient temperatures, long line sets, thermostatic expansion valves (TXVs), or aging components can make startup difficult. In these cases, the compressor may stall, draw excessive current, or trip protection devices. A hard start kit adds a start capacitor and a relay or PTC device to the circuit. At startup, the capacitor delivers a brief surge of energy that significantly increases starting torque. Once the compressor reaches operating speed, the relay removes the start capacitor from the circuit[4].

Key Characteristics

- Provides significant torque boost (often 300–500%)[6]
- Simple and cost-effective installation
- Improves reliability in difficult starting conditions

Limitations

- Does not reduce inrush current[9]
- May increase peak current draw
- Dependent on proper relay operation

In practical terms, a hard start is best understood as a torque solution—it helps compressors start when they otherwise might not.

Soft Start Technology: Controlled Electrical Ramp

Soft start devices take a fundamentally different approach by controlling how power is applied during startup.

Rather than delivering a sudden surge of energy, a soft start uses a micro-controller with solid-state switching (SCR/triac technology[9]) to gradually ramp voltage and current to the compressor. Over several startup cycles, the device learns the motor's characteristics and optimizes its ramp profile.

This controlled startup can reduce inrush current by up to 60–70%[7], significantly lowering electrical stress on the system.

Key Characteristics

- Reduces inrush current and voltage drop
- Minimizes mechanical shock and noise
- Improves compatibility with generators and inverters
- Often includes built-in protections (over/under voltage, over current)

Limitations

- Higher upfront cost
- May have compatibility considerations with certain control boards
- Does not increase starting torque

In simple terms, a soft start is an electrical management solution—it ensures the system starts smoothly and efficiently.

Choosing the Right Solution in the Field

Selecting between a hard start and a soft start depends on identifying the root problem.

When to Use a Hard Start:

- Compressor struggles or fails to start

APPLICATION SCENARIOS: WHEN TO CHOOSE HARD-START VS. SOFT-START

Scenario	Symptoms	Best Choice	Why
Generator/inverter/solar hybrid/ RV	Breaker trips, generator bogs	Soft Start	Cuts inrush up to 70%, saves generator capacity
Weak utility service. Light flicker	Dimming lights at start	Soft Start	Ramps load smoothly
Scroll or recip starting against high head	Stuttering starts, overload trips	Hart Stard (or soft start if power is weak)	Hard start adds torque
Control board monitors current	Comfort Alert/ CoreSense issues	Check Compatibility	Some boards misread soft start signatures
Budget-focused torque boost	Mild start issues	Hard Start	Cheapest and fastest field solution

- High head pressure or TXV systems
- Low voltage conditions[10]
- Aging or worn compressors

When to Use a Soft Start
- Lights dim or power quality issues occur
- Breakers trip instantly at startup
- Generator or inverter applications
- Limited electrical capacity environments

Important Consideration
If a compressor only operates with a hard start—or continues to struggle even with one—the underlying issue may be mechanical failure or system imbalance rather than a startup deficiency.

Installation Best Practices
- Match device selection to the root cause of the issue
- Use one soft start per compressor
- Verify compatibility with control boards
- Avoid masking failing compressors with start-assist devices

Proper application is critical to achieving desired performance and avoiding unintended system issues.

Common Misconceptions
- **"Hard starts reduce inrush current.[9]"** In reality, they often increase peak current while improving torque.
- **"Soft starts fix weak compressors.[4]"** Soft starts do not add torque and cannot compensate for mechanical failure.
- **"Using both provides the best result."** These technologies are designed for different purposes and are not typically used together.

ICM CONTROLS PRODUCT SOLUTIONS
With a clear understanding of application needs, contractors can select from a range of purpose-built solutions.

Soft Start: ICM870 Series (9A, 16A, 32A)
The ICM870 series is designed to reduce inrush current by up to 70%[7] while providing advanced protection and diagnostics.

Key Features:
- Over/under-voltage protection
- Overcurrent protection
- Anti-short cycle delay
- Self-learning algorithm
- LED diagnostics
- IP65 sealed enclosure

Applications:
- Residential A/C and heat pumps (up to ~6 tons)
- Generator and inverter-powered systems
- RV and marine environments

Compatibility Note: Not recommended for use with Comfort Alert boards; CoreSense modules may require bypass.

Hard Start: ICM866U & ICM855–859 Series[6]
- ICM866U: A universal hard start solution supporting 1/12 to 5 HP, featuring advanced relay logic for precise capacitor dropout.
- ICM855–859 (PTCR Series): Pre-wired solutions delivering 300–500% torque boost across various compressor sizes.

Key Benefits:
- Reliable startup under high load conditions
- Fast, simple installation
- Consistent and repeatable performance

Customer Feedback in Relation to ICM Controls Product Solutions

ICM Controls Soft-Start Kits
A homeowner who installed the ICM870-16A reported smoother, quiet starts and said it was a "game changer[8]" for their air conditioner. They also noted peace of mind due to built-in voltage monitoring and over-current protection.

Impact:
- Dramatically reduced noise at startup
- Improved reliability of older AC units
- Increased confidence in equipment protection

Eliminated Circuit Breaker Trips During Hot Summer Peak Loads.
Another customer with an older AC unit said their system used to trip breakers frequently during sum-

mer months. After installing the ICM870, the unit:

- Stopped nuisance tripping
- Required far less power at startup
- Cost less energy to get running

They emphasized the USA-made quality and UL listing as added reassurance.

Impact:

- Stabilized electrical operation
- Improved comfort in extreme weather
- Reduced electrical stress on the home

Reliable Operation on Diesel Generators During Extended Outages

A homeowner using an ICM870-32A to run a 4-ton Carrier system on a 12 kW diesel generator reporting it worked flawlessly after hurricane-related outages.

Impact:

- Enabled whole-home A/C operation during weeks-long generator use
- Smoothed the generator load so it could power both HVAC and essential appliances

RV & Marine Users Considering ICM870 for Lower Cost and Strong Performance

RV owners comparing soft-start solutions noted: The ICM870 costs far less than competitors (e.g., MicroAir). YouTube demos show large residential systems dropping from 70-amp surge to the 20-amp range after installation

RV forum users were specifically impressed by real-world demonstrations showing large reductions in starting current.

Impact:

- Makes running rooftop A/C units on smaller RV generators feasible
- Cuts startup noise in tight RV parks
- Reduces stress on aging rooftop compressors

Competitive Edge

ICM Controls differentiates its soft start and hard start solutions through higher performance, built-in protection, and professional-grade reliability.

The ICM870 soft start series delivers up to 70%[7] inrush current reduction—often exceeding typical claims from generic competitors—while integrating advanced features like voltage monitoring, overcurrent protection, diagnostics[7], and a self-learning algorithm. Its rugged IP65 enclosure and U.S. manufacturing with UL listing further reinforce durability and quality, with some OEMs even adopting it at the factory level.

The ICM866U and PTCR hard start series stand out through precise, high-power relay control that ensures accurate capacitor dropout, helping protect compressor windings. Combined with 300–500% torque boost[6] and pre-wired designs for fast installation, these kits provide more consistent and reliable performance than lower-cost, generic alternatives—making them a preferred choice for demanding, high-load applications.

Conclusion

Start-assist technologies play a critical role in modern HVAC system performance[2]. Hard start kits and soft start devices each provide distinct advantages when applied correctly.

- If the compressor cannot start, the solution is torque (hard start)
- If the system disrupts power, the solution is control (soft start)

There is no universal solution—only the correct tool for the specific problem.

By understanding these differences and applying them appropriately, contractors can improve system reliability, extend equipment life[2], and deliver a better experience for homeowners. With a comprehensive portfolio of both technologies, ICM Controls provides the flexibility needed to address any startup challenge in today's demanding HVAC environments.

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