HVAC Performance KPI Guide

Key Metrics Derived from IoT Sensor Data - What They Measure, Why They Matter, and What Facility Managers Should Know About Each One

How to Use This Guide

This guide defines the key performance indicators that IoT-based HVAC monitoring programs produce from sensor data - and explains what each metric means for equipment health and energy efficiency. It is written for facility managers and building engineers who want to interpret monitoring platform outputs more confidently, engage more effectively with service providers about performance findings, and build a stronger internal case for data-driven maintenance investment. No actual data sets are required to use this guide - it is a reference for understanding what the metrics mean, not for calculating them.

PART 1: EQUIPMENT HEALTH KPIs

KPI 1: DELTA-T (TEMPERATURE DIFFERENTIAL)

Field	Details
What It Measures	The difference between return air temperature and supply air temperature - how much the system is cooling the air as it passes through the unit
Derived From	Supply air temperature sensor + return air temperature sensor
Typical Acceptable Range	16°F to 22°F for most commercial cooling applications - varies by system type and design conditions
Unit	°F or °C

Why It Matters: Delta-T is one of the most direct and accessible indicators of cooling system performance. A healthy system with clean coils, adequate refrigerant charge, and unrestricted airflow produces a consistent delta-T within its design range. A narrowing delta-T - where the supply air is getting warmer and the return air is getting cooler relative to each other - is one of the earliest measurable signals that something in the refrigerant circuit or airflow system is degrading.

What Changes in Delta-T Indicate

Delta-T Condition	Most Likely Cause	Maintenance Implication
Within normal range and stable	System performing as designed	Continue scheduled monitoring
Narrowing gradually over weeks	Dirty evaporator coil · Low refrigerant charge · Airflow restriction	Schedule inspection - efficiency declining before comfort complaint surfaces
Significantly below normal range	Severe coil fouling · Major refrigerant loss · Compressor degradation	Service visit required - system losing capacity
Wider than normal range	Possible airflow restriction on return side · Sensor calibration issue	Verify with technician - may indicate different problem

FM Takeaway: Delta-T trend is more informative than a single reading. A delta-T that is 18°F today but was 21°F three months ago at the same ambient conditions tells a clearer story than a single reading that appears within range.

KPI 2: SUCTION SUPERHEAT

Field	Details
What It Measures	The temperature of refrigerant vapor above its saturation point at the suction side of the compressor - how much the refrigerant has been heated above the point at which it boiled from liquid to vapor
Derived From	Suction line temperature sensor + suction pressure sensor (saturation temperature calculated from pressure)

Typical Acceptable Range	8°F to 14°F for most commercial direct-expansion cooling systems - varies by system design and refrigerant type
Unit	°F

Why It Matters: Superheat is the primary indicator of refrigerant charge adequacy and expansion valve function. A refrigerant system that is properly charged and has a correctly functioning expansion valve delivers refrigerant to the compressor at the correct superheat - enough to ensure the refrigerant is fully vaporized before entering the compressor, but not so much that the compressor is being starved of refrigerant. Superheat outside the acceptable range in either direction indicates a condition that affects both equipment reliability and energy efficiency.

What Changes in Superheat Indicate

Superheat Condition	Most Likely Cause	Maintenance Implication
Within normal range	Correct refrigerant charge and expansion valve function	Continue monitoring
High superheat - above normal range	Low refrigerant charge · Expansion valve restricting flow · Airflow restriction across evaporator	Refrigerant charge verification - leak search if charge confirmed low
Low superheat - below normal range	Overcharge · Expansion valve flooding · High load conditions	Refrigerant charge and expansion valve inspection
Fluctuating superheat	Expansion valve hunting · Refrigerant distribution issue	Expansion valve inspection

FM Takeaway: Superheat requires a technician to interpret in context - ambient conditions, load, and refrigerant type all affect the acceptable range. When your monitoring platform flags a superheat alert, provide the technician with the trend history, not just the current reading.

KPI 3: SUBCOOLING

Field	Details
What It Measures	The temperature of liquid refrigerant below its saturation point at the condenser outlet - how much the refrigerant has been cooled below the point at which it condensed from vapor to liquid
Derived From	Discharge line temperature sensor + discharge pressure sensor (saturation temperature calculated from pressure)
Typical Acceptable Range	10°F to 20°F for most commercial systems - varies by system design and refrigerant type
Unit	°F

Why It Matters: Subcooling provides a complementary view of refrigerant charge to superheat - where superheat reveals conditions at the low-pressure side of the circuit, subcooling reveals conditions at the high-pressure side. Adequate subcooling ensures the liquid refrigerant reaching the expansion valve is fully condensed and ready to absorb heat effectively in the evaporator. Insufficient subcooling indicates refrigerant flashing before the expansion valve - a condition that reduces cooling capacity and efficiency.

What Changes in Subcooling Indicate

Subcooling Condition	Most Likely Cause	Maintenance Implication
Within normal range	System operating correctly at condenser	Continue monitoring
Low subcooling	Low refrigerant charge · Condenser fouling reducing heat rejection · High ambient temperature	Refrigerant charge verification · Condenser inspection

High subcooling	Refrigerant overcharge · Liquid line restriction	Refrigerant charge and liquid line inspection

FM Takeaway: Superheat and subcooling are most meaningful when interpreted together - a technician who has both values in context of current ambient conditions can diagnose refrigerant circuit issues with high confidence without needing to connect gauges for a point-in-time measurement.

KPI 4: COMPRESSOR DISCHARGE TEMPERATURE

Field	Details
What It Measures	Temperature of refrigerant leaving the compressor on the high-pressure side - indicator of compressor operating stress and efficiency
Derived From	Discharge line temperature sensor
Typical Acceptable Range	Varies by refrigerant type and ambient conditions - typically 150°F to 225°F for R-410A systems. Trend deviation from baseline is more actionable than absolute value
Unit	°F

Why It Matters: Discharge temperature is a direct indicator of compressor operating stress. A compressor working in conditions of impaired heat rejection - dirty condenser coils, high ambient temperature, restricted condenser airflow - produces higher discharge temperatures as it works harder to maintain the required pressure differential. Elevated and trending discharge temperature is one of the earliest indicators of compressor stress that, if unaddressed, leads to compressor failure.

What Changes in Discharge Temperature Indicate

Discharge Temp Condition	Most Likely Cause	Maintenance Implication
Within baseline range for current ambient	Compressor operating normally	Continue monitoring
Trending higher over weeks - same ambient conditions	Condenser fouling · Reduced condenser airflow · Refrigerant overcharge	Condenser inspection and cleaning - assess condenser fan operation
Significantly above baseline	Severe heat rejection impairment · Compressor degradation · High pressure condition	Urgent service assessment - compressor failure risk elevated
Suddenly elevated	Condenser fan failure · Refrigerant overcharge · Sudden blockage	Same-day service response

FM Takeaway: Discharge temperature is most useful as a trend metric. A reading that is 15°F above last month's baseline at the same ambient temperature is a more actionable signal than a reading that is at the same absolute value but has been there all season.

KPI 5: VIBRATION AMPLITUDE AND FREQUENCY

Field	Details
What It Measures	The magnitude and frequency pattern of mechanical vibration at rotating components - indicator of bearing condition, rotor balance, and mechanical wear
Derived From	Vibration sensor readings analyzed against established baseline
Typical Acceptable Range	Baseline-relative - deviation from the established normal operating signature for that specific component is the alert trigger rather than an absolute threshold
Unit	g (gravitational acceleration) or mm/s (velocity)

Why It Matters: Every rotating component has a characteristic vibration signature during healthy operation. As bearings wear, rotors become imbalanced, or mechanical components degrade, that signature changes in measurable ways. The rate of change in vibration amplitude - how quickly vibration is increasing - is as important as the current amplitude level. A component whose vibration has doubled in two weeks is a more urgent concern than one whose vibration has increased by the same amount over six months.

What Changes in Vibration Indicate

Vibration Condition	Most Likely Cause	Maintenance Implication
Stable at baseline	Component in good mechanical condition	Continue monitoring
Gradually increasing amplitude	Bearing wear developing · Gradual rotor imbalance	Schedule inspection - replacement before failure preferred
Rapidly increasing amplitude	Accelerating wear · Bearing race damage	Urgent service - failure risk elevated
Spike then return to baseline	Temporary imbalance - debris on blade · Momentary overload	Monitor closely - if spike recurs, schedule inspection
Specific frequency pattern matching bearing geometry	Bearing inner or outer race damage	Schedule bearing replacement - frequency pattern identifies specific failure mode

FM Takeaway: Ask your monitoring provider or service technician whether the vibration alert is an amplitude alert - the magnitude is too high - or a trend alert - the magnitude is increasing. The distinction affects how urgently you respond.

KPI 6: REFRIGERANT CHARGE RATE OF CHANGE

Field	Details
What It Measures	The rate at which refrigerant charge is declining over time - derived from suction pressure trend data. Identifies slow leaks that point-in-time inspection misses
Derived From	Suction pressure trend analysis over time - correlated with ambient temperature to isolate charge loss from seasonal pressure variation
Typical Acceptable Range	Zero charge loss between service visits is the target. Any measurable downward trend in suction pressure at stable ambient conditions indicates active charge loss
Unit	PSI per month or estimated pounds per year

Why It Matters

Slow refrigerant leaks are among the most consequential and most commonly missed maintenance conditions in commercial HVAC. A system losing a small amount of refrigerant per month may appear to be operating normally at any single service visit - the charge is only slightly low, the system is still cooling, and the visit proceeds without identifying the leak. Over time, the accumulating charge loss reduces system capacity, increases compressor stress, and eventually produces a failure or a service call for a significantly depleted system. Continuous pressure trend monitoring identifies this rate of change between service visits - making a slow leak visible as a trend rather than only as a significant charge deficiency.

FM Takeaway: Charge rate of change is the refrigerant KPI most directly relevant to both maintenance cost and regulatory compliance. A system whose monitoring data shows a consistent downward pressure trend at stable ambient conditions needs a leak search - not just a recharge.

PART 2: ENERGY EFFICIENCY KPIs

KPI 7: ENERGY EFFICIENCY RATIO (EER) / COEFFICIENT OF PERFORMANCE (COP) DEVIATION

Field	Details
What It Measures	How efficiently the system is converting electrical input into cooling or heating output - expressed as a ratio of output to input. Monitoring tracks deviation from the unit's rated efficiency under current operating conditions
Derived From	Power consumption data + temperature sensor data used to estimate cooling or heating output

Typical Acceptable Range	Deviation of more than 10–15% from rated efficiency under comparable conditions warrants investigation
Unit	Ratio (dimensionless) or percentage deviation from baseline

Why It Matters
An HVAC system that is consuming 15 percent more electricity than it should for a given cooling output is producing 15 percent more energy cost than necessary - every hour it operates. This waste accumulates continuously and invisibly without measurement. Efficiency deviation monitoring makes this waste visible and quantifiable - connecting maintenance decisions directly to utility cost outcomes.

What Efficiency Deviation Indicates

Efficiency Condition	Most Likely Cause	Maintenance Implication
Within 5% of rated efficiency	System performing as designed	Continue monitoring
10–15% below rated efficiency	Dirty coils · Low refrigerant charge · Airflow restriction	Schedule maintenance - energy waste accumulating
More than 15% below rated efficiency	Multiple compounding issues · Significant refrigerant loss · Component degradation	Priority service visit - significant energy waste and equipment stress
Efficiency declining gradually over months	Progressive fouling or charge loss	Condition-based maintenance intervention before efficiency loss becomes severe

FM Takeaway: Efficiency deviation data is among the most valuable content for internal budget conversations - it converts a maintenance request into a financial return calculation that finance and operations leadership can evaluate.

KPI 8: DEMAND-CONTROLLED VENTILATION PERFORMANCE

Field	Details
What It Measures	How effectively the HVAC system is modulating outdoor air intake in response to actual occupancy - measured by the relationship between CO2 sensor readings and outdoor air damper position
Derived From	CO2 sensor readings + outdoor air damper position feedback + occupancy sensor data
Typical Acceptable Range	CO2 below 1,000 ppm in occupied spaces per ASHRAE 62.1 guidance - outdoor air damper modulating in response to occupancy changes
Unit	ppm (CO2) and % (damper position)

Why It Matters
Demand-controlled ventilation reduces energy consumption by conditioning and ventilating spaces based on actual occupancy rather than fixed maximum assumptions. A system that is delivering maximum ventilation to an empty conference room is wasting the energy required to condition that outdoor air. CO2-based DCV monitoring confirms both that ventilation is adequate when spaces are occupied and that energy is not being wasted when they are not.

What DCV Performance Data Indicates

DCV Condition	Most Likely Cause	Maintenance Implication
CO2 below 1,000 ppm during occupancy · Damper modulating correctly	DCV functioning as designed	Continue monitoring
CO2 above 1,000 ppm during occupancy	Inadequate ventilation · Damper not opening · DCV controls issue	Damper and controls inspection

DCV Condition	Most Likely Cause	Maintenance Implication
Damper at maximum position regardless of occupancy	DCV controls not functioning · Damper stuck open	Controls inspection - energy waste occurring
CO2 elevated during low occupancy	Ventilation adequate but occupancy sensor not triggering reduction	Occupancy sensor and controls integration check

FM Takeaway: DCV performance data directly supports energy efficiency conversations with ownership - CO2 readings that confirm adequate ventilation during occupancy and reduced conditioning during vacancy translate directly into utility cost savings that are quantifiable from occupancy and energy data.

KPI 9: FILTER PRESSURE DROP

Field	Details
What It Measures	The pressure difference across the filter bank - indicating filter loading and the airflow resistance the supply fan is working against
Derived From	Differential pressure sensor across the filter bank
Typical Acceptable Range	Varies by filter type and MERV rating - typically 0.1 to 0.5 inches of water column for standard commercial filters. Alert when approaching manufacturer maximum for the installed filter type
Unit	Inches of water column (in. w.c.)

Why It Matters

Filter pressure drop is the most direct indicator of filter loading - and filter loading has cascading effects on energy consumption, equipment condition, and air quality. A filter that has exceeded its useful loading increases the static pressure the supply fan must overcome, reducing airflow delivery while increasing fan energy consumption. In cooling applications, restricted airflow can cause evaporator coil freeze-up that stops airflow entirely. Filter pressure drop monitoring enables condition-based filter replacement - replacing filters when the data shows they are loaded rather than on a calendar that may replace them too early in some conditions and too late in others.

What Filter Pressure Drop Indicates

Pressure Drop Condition	Most Likely Cause	Maintenance Implication
Below alert threshold	Filter within service life	Continue monitoring
Approaching maximum threshold	Filter loaded - approaching replacement interval	Schedule filter replacement
At or above maximum threshold	Filter overloaded - airflow restriction active	Replace immediately - system airflow and efficiency affected
Sudden increase in pressure drop	Filter collapse · Frame bypass · Foreign material	Inspect immediately - may not be normal loading
Pressure drop not increasing despite high-particulate environment	Filter bypass around frame · Sensor issue	Inspect filter seating and sensor calibration

FM Takeaway: Filter pressure drop monitoring converts filter replacement from a calendar task to a condition-based one - reducing filter replacement cost in low-particulate environments and preventing airflow restriction in high-particulate ones.