

The state of the VFD 2026

A public research and authority report

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Report home, errata, and later editions: <https://waywardleaders.com/state-of-the-vfd-2026>

Abstract Variable frequency drives control approximately 40 percent of industrial motors, and most of what circulates about that market is either the wrong figure or the right figure attached to the wrong basket. This report assesses the current state of the installed technology through a proprietary search design: three frontier AI research instruments and a scholarly harness, run independently against one structured prompt, with declared source ranks, excluded domains, and a classification for every absence. Returns were filtered into a majority report, where the instruments converge, and a minority report, where one instrument produced a document the others had declared did not exist. Nineteen brands were assessed and thirteen scored against a nine-dimension disclosure rubric published here in full. The low voltage AC drive market is approximately \$15 billion growing at about 3 percent rather than the larger figures in circulation, which describe wider baskets. Data center demand is documented at specification level and is not re-rating the drive segment. No drive from any reviewed manufacturer appears in the ISASecure certified components register, not one reviewed brand publishes field return rates, and the rebadging claims used as competitive ammunition are unevidenced and would not matter if they were true. Every claim carries the document number needed to check it, which is the transparency marketing does not reach.

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Highlights and contradictions

Seven places where the public record contradicts something a customer or a competitor is likely to believe. Each carries a source and a section that shows the work.

The rest of this report is the evidence behind those seven, the vendor matrix in section 8, and a shared platform argument in section 5 that will change how you handle a rebadge accusation.

The point of this report

Industrial buyers commit before they can verify. That is the ordinary condition of the work rather than a failure of diligence, because you specify a drive, or you quote one, months before anything about it can be checked against how it behaves in a real plant, and by the time the evidence arrives the purchase order is three years old.

Whatever is available flows into that gap. Marketing, mostly. Folklore, which in this industry is unusually durable. And in at least one case documented here, numbers that appear to have been invented outright.

Credibility is not uniform, though, and it climbs a ladder anyone can follow. At the bottom sits self-report, where the manufacturer says the drive is reliable. Above that is demonstration, where the manufacturer shows something. Above that is the buyer-checkable artifact, a document with a revision number you can retrieve and read without asking permission. At the top is third-party attestation, a certificate with a number, an issuing body, a scope and an expiry.

Self-report is universal and therefore worth nothing. Every drive manufacturer alive claims reliability. The rungs above it are where the differences live, and almost nobody measures them.

That is what this report measures. Not which

drive is best, which no public source can establish. Not who holds the most share, which no public source can establish either. What each manufacturer will put on the public record, at which rung of that ladder, about the things a buyer would want to check.

The ranking that comes out is not the ranking the market believes. A mid-tier North American supplier publishes wear-component life with four stated conditions while 3 of the largest companies in the industry publish nothing comparable. The most complete functional safety data anywhere comes from a company that publishes nothing at all about how long its fans last. And on the disclosure that would matter more than all the others together, field return rates, every manufacturer checked is silent.

That last one is the finding underneath the whole report. 13 companies, and not one of them will tell you how often the product comes back.

What this edition is for

This edition is written for the person who has to put a number in front of a customer who checks.

Most of what circulates about this market is either the wrong figure or the right figure attached to the wrong market. That is not dishonesty, it is what happens when a dozen research houses sell reports built on incompatible definitions and everyone downstream quotes whichever number makes the better slide. Every figure here carries its source and its date, and where the evidence does not support a claim, the claim is named and dropped, including several that would help you sell.

That is the trade being offered. You lose some comfortable talking points. You gain the ability to be the person in the room who is right when somebody looks it up, which in a market growing at 3 percent is worth more than the talking points were.

The contradiction	Evidence
The low voltage AC drive market is about \$15 billion growing at about 3 percent, not \$30 billion at 6 percent	Section 1
No drive from any manufacturer holds an ISASecure certified component entry, so that clause is unmeetable by anybody	Section 8.2
Field return rates: zero of the 19 brands reviewed publish them	Section 8.5
IEEE 519 applies at the point of common coupling, and the 2022 edition states its limits are not for evaluating equipment	Section 10
Safe Torque Off is base build rather than an adder, down to the value tier	Section 10
Global heat pump sales fell about 2 percent in 2025	Section 3
Silicon carbide has not shipped in any general purpose low voltage drive. The silicon shipped and the drives did not	Section 7

Table 1. Highlights and contradictions, with the section where each is evidenced

There is a second use for this, and it is the one worth thinking about. You hold credentials this study does not. Every cell marked (b), gated or channeled, is a document you may be able to pull and a customer cannot. Knowing exactly which questions have public answers, and which do not, is a working advantage in a technical sale, and the matrix in section 7 is a map of where that advantage sits.

This is not a product recommendation, and no manufacturer paid for placement, reviewed a draft, or was contacted during the work. It is not a market forecast either.

Method in brief

Every finding comes from public web search and public document retrieval. Nothing else. No distributor portal, no login, no non-disclosure material, no vendor briefing, no sample unit, no bench measurement, no supplier conversation.

Three frontier AI research tools were run independently against one structured prompt, carrying the same source ranking and the same excluded domains, and a separate scholarly harness was run against an academic works index with live DOI resolution. A finding reached this report only when it survived disagreement between the instruments, and where they split, the split is reported rather than

averaged away.

Absences are classified throughout: (a) appears not to exist, (b) exists but is gated or channeled, (c) could not determine. A low score means the evidence is not public. It does not mean the product is deficient.

Returns were filtered into two layers that the report keeps separate throughout. The **majority report** is what the instruments converge on, and it is the safer material. The **minority report** is what a single instrument produced after the others had declared it did not exist, and across this project the minority report was repeatedly the correct one. The seams between those two layers are where the contradictions in this document come from.

Three limits are worth carrying into section 1. An absence is a statement about one search rather than a fact about the world. Material behind a distributor login is invisible to this method, which biases the result against manufacturers who sell through distribution. And public documents are taken at face value, which is why every document number and revision date is quoted in full.

A note on how absences are worded in this report. Where a section says that something is not published, it means not published by the brands reviewed for this edition, found by these

instruments, in September 2026. It does not mean no company anywhere publishes it. That distinction is the report's own standard applied to its own sentences, and any wording that reads as a universal claim should be read in the narrower sense or reported as an error.

Scope of this edition. Nineteen brands were assessed. Thirteen are scored against the full rubric in section 8. Six are recorded without a score because too little public English-language documentation was reachable at document-number level to rate them fairly, and publishing a low score on that evidence would be unfair: Fuji Electric, Hitachi, TECO-Westinghouse, AutomationDirect, INVT and Veichi. Brands not assessed for this edition include Lenze, KEB, Invertek, LS Electric, Benshaw, Bonfiglioli, Omron and Hyundai. Their absence describes this edition's scope rather than those companies, and extending the set is the first item on the list for the next one.

How this edition is shaped, and how later ones will differ. This is the first edition and it has no predecessor to measure against, so it establishes the terrain rather than reporting a change. It opens on standards and cybersecurity because that is where the public record is most specific, where a clause in a specification can be checked against a certificate number, and where the single sharpest contradiction sits. From that spine it follows the tributaries that open off it: what did not arrive in the product, what the literature will and will not support, what each manufacturer publishes and what it does not, and the places where an interesting number turned out to rest on nothing. A reader looking for one argument will not find one, because a census is not an argument.

Later editions are triggered rather than scheduled, so each will be shaped by whatever triggered it. A drive entering the ISASecure register, a certificate number becoming public, a standards edition landing, or a block of the verification queue resolving: any of those gives the

next edition a spine this one could not have, which is a delta measured against a published baseline. They should be shorter and narrower than this one, and they will be readable only because this edition did the wandering first.

When this is reissued. There is no fixed schedule, because the subject does not move on one. Standards editions are years apart, the certificates in section 8 run to 2030, and the market figure is published annually. This report is reissued when something material changes: a drive entering the ISASecure register, a certificate number becoming public, a new standards edition, a regulatory date arriving, or enough of the verification queue resolving to move the matrix. Every reissue carries its own date and names what changed and who corrected it.

The complete method, the AI involvement disclosure, the competing interests statement and the errors and omissions note are in **Appendix A**. The scoring rubric every matrix cell was scored against is in **Appendix B**. Corrections go to carl@waywardleaders.com.

1. The number, and why the one in your deck is probably wrong

All three instruments led with the same figure, found independently.

Interact Analysis, 19 May 2026: the low voltage AC motor drive market was \$14.4 billion in 2025, is \$14.9 billion in 2026, and reaches \$17.0 billion by 2030. About 3.4 percent average annual growth.

Regional split, corroborated by 2 of 3: **Asia Pacific excluding Japan 38.5 percent, EMEA 29.8 percent, Americas 25.6 percent, Japan 6.1 percent**, with the Americas carrying the highest forward growth at **4.5 percent**.

Every figure larger than that widens the basket.

One instrument assembled nine research houses and found 2025 global estimates run-

ning **from \$7.35 billion to \$38.1 billion. A factor of 5.2**, for a market nobody disputes exists. Another made the cleanest analytical point in the entire project: MarketsandMarkets includes AC, DC and servo across low and medium voltage. Mordor's "electric drives" includes servo. QYResearch's "general purpose inverter" excludes HVAC-specialist and servo-heavy revenue. **Different baskets, not different arithmetic.**

And there is an internal contradiction that settles it. Future Market Insights states that low voltage VFDs are 60.8 percent of market value, and puts 2025 at \$38.1 billion. That implies roughly **\$23 billion of low voltage VFD value in a year Interact Analysis measures at \$14.4 billion.** Both cannot be right, and the gap between them is larger than the annual growth either forecasts.

The line you can defend: the low voltage AC drive market is roughly \$15 billion growing at about 3 percent, not \$30 billion growing at 6 percent. The larger figure is not wrong. Calling it the low voltage AC drive market is.

This matters to you commercially in a specific way. A customer who has read a \$38 billion number and a 6 percent growth rate has a mental model in which everybody is expanding and capacity is the constraint. A 3 percent market behaves differently. It is a share fight, not a rising tide, and the conversations that win in a share fight are technical rather than aspirational.

One more thing nobody can give you. No public low voltage AC drive vendor share table exists. Interact holds one for vendors above 1 percent and it sits behind the report price. **Anyone quoting "ABB leads with X percent" without naming that report is quoting nothing.** And none of the brands reviewed publishes a drives revenue line. Every vendor figure you have ever seen is a segment proxy containing motors, servo, traction or services.

2. The data center story is a switchgear story with a drive attached

This is the strongest finding in the commercial leg, and it will be uncomfortable, because it is currently the most-used story in the industry.

ABB will not quantify its data center drive content, and volunteered that it grows slower than switchgear.

The numbers come from ABB's own Q2 2026 reporting. **Electrification orders rose 58 percent to \$7.2 billion**, on triple-digit data center order growth. In the same quarter, **Motion, the business containing drives, grew orders 20 percent, grew revenues 4 percent, and saw operational EBITA margin fall 130 basis points to 18.5 percent.**

Asked directly on the call by HSBC how much of Motion is data center cooling, and whether that too was triple-digit, **ABB gave no figure**, and its Head of Investor Relations added that the growth rates are not as high as in Electrification. ABB separately described its role as a component supplier to the cooling companies, and noted that the same units often sit on a commercial building, so data center and commercial HVAC are not cleanly separable even inside ABB's own reporting.

The inference, and it is labeled as an inference: a drives salesperson reading "data centers are transforming the drives market" is reading a switchgear story with a drive attached.

Now the other half, because this is not a debunk and the honest version is more useful than either extreme.

Data center drive content is documented at specification level. Open Compute Project's Project Deschutes, dated 1 July 2025, contains a dedicated VFD section, and approved 2 MW coolant distribution unit designs from Boyd, Vertiv, nVent and others specify **IEEE**

519 ultra-low-harmonic drives. That is unusually strong evidence, because the requirement sits inside a shared design standard tied to multiple real suppliers, rather than inside a forecast.

Both halves are true and you should carry both. The drive content is real and it is specified. The segment is not re-rating a \$15 billion market growing at 3 percent. **What is documented is existence. What is projected is magnitude.**

How to use this. Do not lead with the data center boom, because a sophisticated customer has already noticed that their drive business did not triple. Lead with Deschutes, because it is a specification you can hand them, with named suppliers and a harmonic requirement attached. Specification-level knowledge is worth more in a share fight than a growth narrative, and it is the thing your competitor will not have read.

3. Demand drivers that are not

Heat pumps

Global heat pump sales fell about 2 percent in 2025. That is the IEA's 2026 Global Energy Review, which is about as authoritative as a demand-side source gets. Europe recovered about 11 percent; the United States declined; China and Japan were broadly flat.

Every drive-market story listing heat pumps among current growth drivers is quoting a projection over a year of declining unit sales. Drop it.

The lead time crisis

No drive-specific lead time dataset exists. Published 2026 electrical equipment lead time indices cover transformers and switchgear and exclude drives entirely. That is the whole evidentiary position.

And the one primary statement that exists

points the other way. **ABB's chief executive, asked directly whether record orders reflected extending lead times, said lead times are similar to before and there are no pre-buys.**

One instrument turned up a 12 to 22 week VFD lead time figure from a single trade brief dated 26 June 2026, and flagged it itself as worth watching rather than worth quoting. It did not corroborate in the commercial leg. **Do not build a buy-now urgency close on it.** If lead times at your own branches are genuinely extending, that is real data and it is yours, and it beats a number you cannot source.

The component squeeze

The 2026 squeeze is memory and metals, not power semiconductors. No vendor named IGBT or module allocation as a current constraint in any material reviewed.

That is a specific and useful correction because the two constraints move on completely different clocks. **Do not import memory lead times into a VFD quote,** and do not let a customer do it to you either.

Which end markets are actually weak

three independent companies in the same quarter named overlapping weak segments. ABB named chemicals and pulp and paper. Rockwell named food and beverage and process. Yaskawa named oil and gas.

Process industries are not funding this recovery. If your territory is weighted to process, your number is not a performance problem, and that is worth knowing before a quarterly review.

4. The China question, stated precisely

This is the topic where the most is asserted and the least is evidenced, in both directions.

Inovance leads China and has not displaced anyone globally. Its domestic share is roughly **19.6 percent**, a Frost and Sullivan estimate disclosed inside an April 2026 HKEX application proof. Treat it as what it is: a research house estimate inside a company filing, single source, not independently triangulated. Its **overseas sales are 5.87 percent of group revenue**, from the Hong Kong listing document. A second instrument reported close to 12 percent, citing a consultancy blog reading company material, and flagged its own source as weak. **Use 5.87 percent. It names the filing.**

Chinese displacement is documented inside China and not outside it. No customs data, no ex-China share table, and no import volume series was located by any instrument. The most-cited supporting line for Veichi's export growth is a research-house sentence footnoted to veichi.com.

The sharpest way to state the whole thing comes from comparing two published top-five lists. QYResearch's general purpose inverter top five for 2025 is Siemens, Danfoss, **Inovance**, ABB and Yaskawa at 44.10 percent combined. Mordor's low voltage electric drives top five is ABB, Siemens, Schneider, Danfoss and Rockwell at roughly 45 to 50 percent. **Those two lists are not describing the same market, and Inovance is inside one and outside the other.** That single observation is the Chinese entrant story told accurately.

One piece of evidence does point at real pressure. Yaskawa disclosed that it accelerated restructuring in China including **downsizing Drives production capacity**. That is the only located evidence of an incumbent physically shrinking in response to Chinese pricing, and it is inside China.

5. Shared platforms, and why the re-badge argument is a dead end

Two claims circulate constantly here and both get used as competitive ammunition: that AutomationDirect's DURApulse is a labeled Delta Electronics drive, and that Toshiba drives are rebadged Schneider. Neither was established in this work. One of them has a public record that surprises most of the people who repeat it.

Schneider Toshiba Inverter SAS was formed in 2000 at Pacy sur Eure in Normandy, Schneider 60 percent and Toshiba 40 percent, building general purpose inverters up to 630 kW and selling them under both badges. That is public, it is uncontroversial, and it puts Toshiba as the minority partner in a Schneider-controlled entity rather than the reverse. The entity is still active as Schneider Toshiba Inverter Europe SAS. Whether any particular current product came out of it is a separate question the public record does not settle, and the chronology test applies as it does everywhere: a venture formed in 2000 establishes nothing about a platform launched two decades later.

Now the part worth more than the answer. Suppose it is all true. Suppose every shared-platform rumor in this industry checks out exactly as told. So what.

Shared manufacturing is ordinary. In any industry where a supplier sells at 3 levels, components, assemblies, and complete designs, the same hardware appears under several badges, and nobody in automotive or appliances or aerospace treats that as a scandal. A supplier who will sell you a module, or a subassembly, or a finished design with your name on it is running an ordinary business.

The logic also cuts both ways, which is what makes the argument a dead end. If a shared platform is inferior, it is inferior under every sticker on it, including the one being sold by whoever raised the point. If it is sound, it is sound under both. Learning that two drives

share a board tells a buyer almost nothing about either one.

What differs between badges is everything this matrix actually measures, and 2026 is the year that stopped being arguable. Certification scope varies enormously between companies whose hardware may well overlap: ABB holds 968/CSP 1036.00/25 for the ACS880 and holds nothing comparable for the ACS580, while Schneider's genuine 62443-4-2 certificates cover a soft starter and a UPS card rather than any Altivar. Toshiba publishes capacitor and fan life with four stated conditions and ABB, Siemens and Schneider publish nothing comparable. Firmware downloads free and public from some, and is channel-controlled by others who say so plainly in their own documentation.

None of that is decided by who etched the board. It is decided by what the company chose to publish, certify, stock, support and stand behind: parts availability and lead time, documentation and firmware access, who answers the phone on a Saturday, how the warranty is administered, whether the commissioning software costs anything, how deep the spare stocking runs, and whether an application engineer will take the call. That is the ecosystem, it is what a badge actually sells, and by 2026 the distance between ecosystems is wider and far easier to verify than any distance between the boards.

So the rebadge question is the wrong question. The one that pays is narrower. What does this badge give me that the other one does not, in certification scope, documentation, parts and support. The matrix answers that, and answering it requires nobody to settle a rumor.

The commercial lesson underneath all of this. Rebadge claims are the most repeated and least evidenced statements in the industry, and using one in a competitive situation puts you one curious engineer away from losing credibility on everything else you said. The

argument also does not survive its own logic: a platform bad enough to disqualify a competitor is bad enough to disqualify whoever else ships it, and that may include the line in your own bag. Sell the ecosystem instead, because that is where the differences are real, documented, and in your favor or not on the evidence rather than on a rumor.

6. Tariffs: what is established and what is not

Read this before the figures below. Whether AC drives appear by HTSUS code in the Section 232 Annexes was not confirmed by any instrument in this work. Do not quote a tariff rate for drives without pulling the Annex yourself. The rates that follow are real and published; their application to a drive is what is unestablished.

Two mechanisms, and neither is fully resolved for drives specifically.

Section 301. 25 percent on Chinese-origin drives, reported by two instruments, one with **CBP ruling N319897** placing a VFD controller under HTSUS **8504.40.4000**.

Section 232, and this is where it gets unresolved. Two 2026 proclamations, one dated 2 April and effective 6 April, and **Proclamation 11032 of 1 June effective 8 June**, moving from taxing metal content to taxing **full customs value**, with tiers at 50 percent, 25 percent, a temporary capped 15 percent for metal-intensive industrial and grid equipment through 2027, and 10 percent where metal content is at least 85 percent United States origin.

Whether AC drives appear by HTSUS code in the Annexes was not confirmed by anyone. The 15 percent industrial category plausibly reaches an enclosed drive assembly and plainly does not describe a bare drive module. **Do not quote a tariff rate for drives without pulling the Annex yourself.**

What you can defend right now is Rockwell's own disclosure: about 100 basis points of its roughly 250 basis points of FY2026 price realization is tariff-related, and tariffs are EPS neutral because pricing offsets cost. That is a public company telling its investors how much of its price increase is tariff pass-through, which is a far better answer to "why did the price go up" than a rate you cannot source.

7. Claims you cannot defend

Each of these is in circulation. Each fails against the public record. If you are using any of them, a technically literate customer can embarrass you.

"Silicon carbide is transforming drives." Every general purpose low voltage range from ABB, Siemens and Danfoss remains silicon IGBT. The confusion has a clean cause: **the silicon shipped and the drives did not.** on-semi announced EliteSiC SPM 31 modules on 24 March 2025. Mitsubishi began sampling Full-SiC and Hybrid-SiC SLIMDIP modules on 22 April 2025. Component launches read like product launches in trade coverage. Commercial SiC drives exist and are specialist: SmartD's Clean Power VFD, datasheet SDB-2-2375-A dated 29 January 2026, 575 V, 105 kHz nominal and 210 kHz effective switching, 96 percent efficiency, IE2, all figures manufacturer-stated. **And no independent efficiency measurement of any commercially shipped SiC low voltage drive exists**, including in the peer-reviewed literature, where every SiC inverter efficiency result since 2018 is a laboratory prototype.

"Gallium nitride is coming to drives." three instruments searched and found none in industrial low voltage product. The GaN that shipped in 2025 and 2026 is 400 to 600 W appliance and servo silicon: Navitas at PCIM May 2025, ST GANSPIN611 and GANSPIN612 in production 24 November 2025, EPC integrated stages in mass production 26 August 2026. Not 400 V

industrial frames.

"Active front ends are becoming standard." Manufacturer catalog structure says otherwise: six-pulse, low harmonic and regenerative are still sold as different architectures at different prices. And the regulation runs the other way. **EU Regulation 2019/1781 exempts regenerative drives and sub-10 percent THDi drives from the IE2 obligation.** AFE is sold on application, not on efficiency rules.

"EU efficiency requirements are about to tighten, buy now." The IE2 minimum has applied since 1 July 2021 and stands. The review runs from December 2024 into spring 2027, with a reported Commission adoption aim of 2029 and a reported stakeholder meeting on 24 September 2026, both single-source. **Nothing is imminent.** In the United States, no federal VFD efficiency standard exists or is in rule-making, and the DOE Process Rule NOPR of 7 July 2026 makes future standards procedurally harder, not easier.

"Our drive predicts bearing failure." The published evidence does not support it. The academic field is dominated by machine learning on one dataset, the Case Western Reserve University bearing data, which is accelerometer vibration from a single test rig with seeded faults. A model at 99 percent accuracy on CWRU has not been shown to work on another motor with a naturally progressing fault. Bearing current behavior under fast switching traces to essentially one research group. No accelerated life test or field return data has been published linking faster switching to reduced bearing life. **Every instrument in this project reached the same conclusion, and it was the strongest convergence in the entire body of work.**

The author works in this space and applies the same standard to his own numbers. ORCA-VFD (Tolbert, 2026b) reports R^2 of 0.9991 for sensor-less remaining useful life from eight standard drive parameters, and the trajectory it

recovers was synthesized, the monitored ABB ACS880 ran at 20 percent to 30 percent of motor full load current, and no failure occurred during the 720 hour window. The paper's own abstract calls it a proof of concept rather than a field-validated failure predictor. If you are selling against a competitor's prognostics claim, that is the question to ask: validated against what failures, on whose equipment, over what window. Almost nobody can answer it, including the people who publish in the field.

"Integrated motor drives are new." SEW documented MOVIMOT integrated motor-inverter gearmotors around 2010. Siemens announced the SINAMICS G115D, combining motor, converter and gearbox in one unit, on **2 November 2020**. The chronology test kills the claim.

The customer objection to integration is better than the claim, though, and you should know where it stands. If the drive and the motor are in one package and they do not wear out at the same rate, the first failure replaces both. The mechanism behind that objection is documented: a drive's life runs on DC bus capacitors and fans, which Toshiba publishes at 10 years under 4 stated conditions and KEB says can begin failing around 5 years against a typical 7 to 12 year expectancy, while a motor's life runs on bearing L10 and insulation thermal aging. Different physics, different intervention, and re-greasing does nothing for an electrolytic capacitor. The number that would settle the argument was not found. None of the brands reviewed publishes a failure rate for an integrated motor-drive unit, and none publishes drive field return rates at all. If you sell integrated drives, that gap is worth knowing before a customer finds it. If you sell against them, the honest version of the objection is stronger than the folklore version.

"Our MTBF is better." Almost none of the brands reviewed publishes MTBF, and that is to their credit. Telcordia, MIL-HDBK-217 and IEC

61709 produce materially different numbers for identical hardware. **Two MTBF figures from two manufacturers are usually not comparable at all**, and a customer who knows that will treat the comparison as evidence you do not.

"Brand X locks you out of your own drive." Mostly false in 2026. See section 7.4.

8. The vendor disclosure matrix

Nobody can rank these companies on share. So this ranks something you can actually use in a competitive conversation: **what each manufacturer will put in a public document with a revision number**.

That is not a proxy for quality, and using it as one will get you caught. **A low score means the evidence is not public. It does not mean the product is deficient.** Rockwell's engineering material sits in its literature library and PCDC. Siemens routes through SIOS and the Industry Mall. Those are disclosure postures.

But disclosure posture is commercially real, because it determines what an engineer can verify before they buy, and increasingly what a specification can require.

three family scores, never summed. Compliance out of 12. Engineering evidence out of 9. Operator reality out of 6.

8.1 The matrix

What these integers are, and what they are not. They are ordinal scores, not measurements. They rank manufacturers against each other on how much a buyer can retrieve and read without asking permission, and they were assigned against the rubric published in Appendix B, which is where an argument with any cell should start. Treat the ordering as the finding and the integer as shorthand. Where a cell looks wrong, the notes column and section 12 name the documents the score rests on, and a

correction lands on that cell.

Lighter treatment, insufficient evidence to score: Fuji Electric, Hitachi, TECO-Westinghouse, AutomationDirect, INVT, Veichi. Notes in section 8.6.

8.2 The headline that opens any competitive conversation

No drive from any manufacturer appears in the ISASecure certified components register. The public ISA/IEC 62443-4-2 list was pulled on 14 September 2026. Roughly 80 entries from ABB, Schneider, Honeywell, Emerson, Yokogawa, Hitachi, Toshiba Infrastructure Systems, Cisco and Johnson Controls. Every one is a controller, safety system, switch, firewall, RTU, gateway or chiller controller. **Not one drive.**

Commercially, that means a specification clause reading “component shall hold ISASecure CSA certification” is currently unmeetable by anybody, including you and including every competitor. If you see that clause, the right move is to get it changed before bid, not to no-bid and not to quietly take an exception that comes out at submittal.

What is meetable, with numbers. ABB’s ACS880 holds **968/CSP 1036.00/25**, TÜV Rheinland, issued 4 July 2025, IEC 62443-4-1:2018 and 4-2:2019, **Security Level Capability 1**, valid to 4 July 2030, scoped to UCU-based ACS880 variants in V1.30.x and V1.31.x firmware. Rockwell holds comparable attestations for PowerFlex 755T and 6000T.

Know the certificate limits before you quote against them. ACS580, ACQ580 and ACS180 have **no** such certificate, and ABB’s medium voltage certificate 968/CSP 1071.00/26 is not a low voltage ACS certificate. Schneider holds genuine 62443-4-2 certificates, **968/CSP 1017.00/24 for the ATS490 soft starter** and one for a UPS network management card, and **neither covers an Altivar drive.** Toshiba ap-

pears in the ISASecure register as **Toshiba Infrastructure Systems and Solutions Corporation** for a 2017 DCS controller, a different legal entity from Toshiba International Corporation, and not a drive.

Claimed but not numbered: Danfoss VLT, announced 16 April 2026, number never came out. Siemens next-generation SINAMICS, stated certified by UL Solutions at **SL-C 2**, which would be the highest level claimed by any drive, number not public. Eaton DX1 and Inovance in the same posture.

And note the direction of causation, because it is unusual. Certified product exists **ahead of** the demand for it. No tender or standard specification requiring 62443-4-2 of a drive was located anywhere in this work, despite certified product since early 2025. The manufacturers built it before anybody asked.

8.3 Disclosure does not track company size

Toshiba International, a mid-tier North American supplier, scores 8 on engineering evidence and a perfect 6 on operator reality, beating Siemens, Schneider and every Chinese entrant.

Its AS3 page serves instruction manuals, extended manuals, communications files, the STO safety manual, a leakage current guide, an engineering specification at revision 9/25/2024, motor matching guidance, a start-up check sheet and a predictive monitoring guide, with no login.

The wear-life disclosure is the single most quotable thing in this report. Toshiba’s AS3 Predictive Monitoring Product Guide, Rev. 11ESSENCE0824 (2024), states a **10 year design life** for the smoothing aluminium electrolytic capacitors; **10 year cooling fan life** for VFAS3-2004P to 2550P and 4004PC to 4132KPC; and **5 year main fan with 9 year inner-air fan** for 4160KPC to 4280KPC. Reference conditions stated: **40 °C average am-**

Vendor	Compliance /12	Engineering /9	Operator /6	Notes
ABB	9	8	4	Best certificate transparency, best safety data document in the industry
Toshiba TIC	5	8	6	Only manufacturer publishing wear component life with stated conditions
Danfoss	7	8	5	Best functional safety guides, hardware revision appendices
Rockwell	7	7	5	Only drive family besides ABB with a public certificate number
Siemens	7	7	3	Best loss-point data in the set. Software access the weakest cell
Eaton	5	6	3	Function-by-function safety disclosure, stale standards citations
Mitsubishi	5	6	4	Strong safety architecture, parameter copy to ordinary USB
Schneider	4	6	3	Certificate trail weaker than the marketing
Nidec / Control Techniques	4	5	4	Open legacy library, stale platform
Yaskawa	4	6	3	Concise conditioned performance data, software behind a request form
WEG	3	4	2	Firmware is channel-controlled and says so
Delta	3	3	2	STO certificate displayed as expired October 2024, no renewal located. Number in section 12
Inovance	3	3	2	SL2 certificate file exists, scope unresolved

Table 2. The vendor disclosure matrix. Family scores are reported separately and never summed

bient, 65 percent relative humidity, at or below 80 percent load factor, 24 hour operation per day.

two instruments searched for exactly this across the whole industry and declared an absolute vacuum. One found this document. **The vacuum is real across the majors and one mid-tier supplier fills it.**

And here is the part with commercial teeth. **The vacuum is being filled by fabricated numbers.** The top organic search result for VFD capacitor life asserts that most drive manufacturers rate their products for 100,000 hours or more of powered operation at rated load and ambient, citing no manufacturer at all. Toshiba's real document says roughly half that,

with four conditions attached. If a customer quotes the 100,000 hour figure at you, you now have a real number from a real manufacturer to put next to it.

8.4 Commissioning access is far more open than the folklore says

This surprised every instrument, and it kills a competitive talking point that gets used constantly in both directions.

ABB's Drive Composer Entry is free. Rockwell's Connected Components Workbench Standard Edition is a free public download and 755TS firmware is publicly downloadable through PCDC. Danfoss MCT 10 Basic is free. Schneider's ATV600 firmware was pub-

licly downloadable in May 2026. Mitsubishi's FR-A800 copies parameters to **ordinary USB memory**, not a proprietary module. Keypad-only commissioning is universal. Parameter lists are in published firmware manuals at stated revisions.

two documented exceptions. WEG states plainly that firmware cannot be downloaded through WPS and must be obtained from WEG or supplier technical support, which is the clearest channel-control statement anyone makes and at least it is honest. Yaskawa's DriveWizard Industrial requires an online request form. Siemens is structurally different rather than restrictive: Startdrive lives inside TIA Portal licensing rather than existing as a free standalone tool.

If you are using "they lock you out of your own drive" against a competitor, check it first. In most cases in 2026 it is not true, and the two cases where something like it is true are documented and easy to state accurately.

8.5 Best in class, by dimension

ABB's safety document deserves naming, because it is the benchmark you can hold anybody to: **3AXD10002751766 Rev A, dated 25 February 2026**, giving PFH to two significant figures per frame size per option code, with PFDavg at two proof test intervals, diagnostic coverage, systematic capability, category, hardware fault tolerance, common cause factor, mission time, and a written statement of the demand assumption. Worked example: option +Q963, frames R6 to R8, SIL 3, PL e, PFH 4.6E-08 per hour, PFDavg at a 2 year proof test interval 2.8E-04, DC at least 90 percent, HFT 1, CCF 80, mission time 20 years.

And the same company publishes nothing about how long the fan lasts. A specifier can compute a SIL verification from ABB's public data and cannot compute a maintenance budget from it. That gap is the shape of the whole industry.

Rockwell deserves a separate note. It publishes the most sophisticated component remaining-life model in the set, estimating remaining life of IGBTs, fans and blowers, DC bus capacitors, circuit breakers, LCL capacitors and filters from temperature, air quality, airflow, voltage, runtime, cycles and drive size. Genuinely useful, and **it is a model driven by operating history, not a published L10 rating and not field reliability data.** Do not let it get relabeled as either in a quote.

Field return rates: not one of the brands reviewed publishes them. Classified (a) across the board on the evidence reviewed here: not found, not produced. It would be the single most valuable disclosure any drive manufacturer could make.

8.6 The lighter vendors

Fuji Electric. FRENIC-GS launched 30 May 2024, a genuinely recent platform. Publishes component life monitoring with remaining-life indicators for main circuit capacitors, control capacitors and cooling fans. Software via Fe-Library, so access is (b). Current product page still cites UL 61800-5-1 Edition 1 and CSA C22.2 No. 274.

Hitachi. A repair shop technical compilation cites the Hitachi SJ300 and L300P service manual giving cooling fan life of approximately 35,000 hours, about 4 years. Single source, primary unverified. If it confirms, Hitachi joins Toshiba as the only manufacturers publishing a wear interval.

TECO-Westinghouse. Publishes **list pricing** on its open manuals page, which no other vendor in this set does.

AutomationDirect. Transparent by business model, since it sells online. GSoft2 is a free download. GS30 documentation states 100 percent conformal coating to **IEC 60721-3-class 3C2**, a specific environmental citation larger vendors omit. Its DURApulse GS4 lists

STO and 100 kA SCCR as standard up to 300 horsepower. And it openly resells Toshiba, saying so in its own AS3 literature, with an extended warranty offered when the drive is paired with Toshiba SD series motors, which is a plainly documented distribution relationship rather than a rumored one.

INVT and Veichi. Recorded as unassessed rather than as poor disclosers. Neither instrument reached English technical documentation at document-number level. Publishing a low score for either would be unfair on this evidence.

9. The one new obligation that becomes a line item

In 3 years, the only genuinely new legal obligation placed on a drive is cybersecurity, and it is already live.

Regulation (EU) 2024/2847, the Cyber Resilience Act. In force 10 December 2024. Chapter IV from 11 June 2026. **Article 14 reporting live since 11 September 2026, and applying to products already on the market.** Full essential requirements and CE marking from 11 December 2027. The reporting clock: **24 hours early warning, 72 hours full notification, 14 days final report.**

Why this matters to a channel business specifically. Certification has so far been a preference. CRA conformity is a condition of sale. The line item that appears next in tender documents is not “shall be 62443-4-2 certified”, it is CRA conformity plus a named vulnerability contact, because one is a differentiator and the other is law.

three practical consequences. First, any principal you carry who sells into the European Union needs a position on 11 December 2027, and you should know what it is before a customer asks. Second, the obligation reaches installed product, which means it touches your service and retrofit business and not only new

orders. Third, and most useful: **“who receives a vulnerability report about this product, and what happens in the first 24 hours” is a question almost no competitor is prepared to answer**, and it costs you nothing to be the one asking it.

10. Where the specification actually gets won

three places where knowing the document beats knowing the product.

IEEE 519 belongs at the point of common coupling. The 2022 edition carries an **explicit scope note stating that the limits apply at the PCC and are not intended for the evaluation of equipment.** Voltage limits unchanged. Even-order current limits relaxed: at or below the sixth harmonic to 50 percent of the tabulated limit, above the sixth to the full limit, against a blanket 25 percent in 2014.

And a major utility’s standing specification gets this wrong. American Water publishes section 26 29 23, revised 2021, stating that the VFD unit shall meet all IEEE 519 requirements for individual and total harmonic distortion. That applies 519 to the unit, which the governing edition explicitly disowns.

Use this carefully and it is the most valuable thing in this report. **It can lose you a filter sale and win you a customer.** A specification written at the unit is potentially buying low-harmonic or active front end hardware the standard does not require at that measurement point. Whether the customer still wants it is a real engineering question about their transformer and their system impedance, and having that conversation honestly is worth more than one order.

Safe Torque Off is standard now, not an option. AutomationDirect’s DURApulse GS4 lists STO and 100 kA SCCR as standard up to 300 HP. Toshiba’s AS3 puts STO on a detachable terminal strip. Control Techniques puts

dual-channel STO at SIL 3 and PL e in every Unidrive M. **A specification that calls STO out as a priced option is reading a market that no longer exists**, and a competitor still quoting it as an adder is exposed. Safe Stop 1 is moving into base build too: Danfoss extended PROFIsafe and SS1-t across all iC7-Automation sizes on 30 January 2026, and NORD integrated STO, SS1, SLS, SMS and SSM into NORDAC ON on 6 July 2026.

“Complies with 61800-5-1” is not a specification. IEC 61800-5-1 Edition 3.0 is dated August 2022, with corrigenda September 2023 and December 2025. **UL 61800-5-1 Edition 2 was ANSI-approved 24 June 2022 and is still rooted in the 2007 IEC second edition.** two standards with nearly the same number and nearly the same approval date, 15 years apart in content. CSA C22.2 No. 61800-5-1:25 replaced No. 274 in June 2025, with the **certification transition running to 1 September 2027.**

That last date is a real commercial event. Eaton’s DG040001EB cites UL 508C and CSA C22.2 No. 274-13, two editions dead. ABB, Rockwell, Mitsubishi and Fuji documents still cite No. 274 somewhere. **Today that is stale disclosure, not an invalid listing.** After September 2027 it becomes a different question, and anybody still shipping literature citing No. 274 at that point has a problem.

Real procurement documents are worth reading. two worth knowing, because they show what buyers actually write: Wake County’s August 2023 building automation guideline requires Modbus and BACnet capability with speed, current, voltage, power, energy and alarms delivered into the building automation system. A 2024 water and wastewater pump station design standard requires VFDs on larger 460 and 480 volt motors with NEMA 4X construction and IEEE 519 provisions. Neither is a forecast. Both are what somebody put in a bid package.

11. The regulatory calendar

Not one item on that list is a technology transition. All of it is regulatory, all of it has a date, and all of it is knowable in advance. That is the opposite of the silicon carbide timeline, which has been 18 months away for 7 years.

12. How to check this document

Ordered by cost of being wrong. Every item is one download away.

- **The ISASecure register.** Pull it and date the retrieval. It opens section 7.2 and it should be checked on the day you use it.
- **Toshiba AS3 Predictive Monitoring Product Guide, Rev. 11ESSENCE0824.** The most quotable numbers in this report rest on one instrument’s reading.
- **The Penrose audit of the EPRI and IEEE motor reliability studies**, and the origin of the “bearings cause 41 percent of motor failures” figure. Single source, unverified against the primary studies, and it contradicts a number that has been repeated in this industry for 40 years. Pull the EPRI 1983 report and the IEEE 1985 and 1995 surveys before quoting either version.
- **Siemens SINAMICS G115D announcement date**, given here as 2 November 2020 from the Siemens press release. An earlier draft of this work carried July 2023, which was wrong.
- **Section 232 Annex HTSUS lists**, to establish whether and how drives are covered. Nobody confirmed it.
- **ABB certificate 968/CSP 1036.00/25** and safety document **3AXD10002751766 Rev A.** Both are quoted in this report and both are public.

- **American Water specification 26 29 23**, since the IEEE 519 finding is the most actionable thing here and rests on one report.
- **Inovance overseas percentage**, 5.87 against 12. Pull the HKEX document.
- **Siemens SL-C 2 certificate number**, still not public after three instruments and two research legs.
- **Danfoss VLT 62443-4-2 certificate number**. Announced 16 April 2026, never came out.
- **Inovance certificate file “IEC62443-4-2 SL2-CBSCY 092835 0419 Rev.00”**. Pull it and confirm whether the scope covers a drive.
- **Delta STO certificate 01/205/5429.04/19**, displayed as expired 23 October

2024. Confirm before repeating the lapse.

- **Inovance MD520HS hybrid SiC**. two instruments, one trade article. Needs an Inovance document.
- **The DURApulse and Delta question**, via the UL or FCC applicant of record for a specific catalog number.
- **Toshiba’s current stake in Schneider Toshiba Inverter Europe SAS**. LEI parent fields do not answer it.

If you check one of these and find this report wrong, that is the system working. The classification scheme exists so a correction lands on one cell instead of discrediting the table. And a correction showing that a document exists behind a distributor login proves the central point rather than refuting it: the data was there, and it was not public.

Abbreviations

Appendix A: Method, AI Involvement, and Authorship

The Question Behind the Census

Every drive brand a buyer can specify in North America publishes something, and several publish a great deal, yet no one appears to have read all of it against a single set of questions, scored it against a single scheme, and placed the result where anyone could check it. That absence defines the project. The work is a census of disclosure, recording what each manufacturer currently available to a North American buyer has committed to the public record, read the same way, scored against the same criteria, with every absence classified rather than assumed. Questions about which drive performs best in service fall outside what the public record can settle, and this report does not attempt them.

The project originates in the author’s own research on this equipment. Tolbert (2026b) reported that among published predictive maintenance studies for VFD and motor systems, only 10.15 percent validate their approaches against genuine operational data from functioning industrial equipment, while the remainder rely on laboratory test stands, simulated signals, or artificially injected faults, and that laboratory-validated models deployed into the field reach false-positive rates approaching 30 percent. That finding concerns the scholarly literature. The question motivating the present work is whether the manufacturer literature exhibits the same structure, and the sections that follow answer that it does: claims circulate widely, retrievable evidence standing behind them is scarce, and the distance between the two is where a specifying engineer absorbs the cost.

The Instruments

three frontier models were run independently against a CASINO search design, the author's structured research prompt format, which specifies the scope areas, a source ranking from R1 through R5, an absence classification, a set of excluded domains, and a requirement that each return declare its own source ranks. Several open-weight models were run separately through a scholarly harness against an academic works index with live DOI resolution, an instrument that produced provenance findings the web-searching tools could not, among them the observation that the condition monitoring literature rests substantially on a single seeded-fault dataset. Author time on design, adjudication, structuring, and correction totaled approximately 20 hours.

Instrument selection was itself a research decision, and it narrowed the field deliberately. Gemini, Copilot, Perplexity, and comparable retrieval-weighted assistants were excluded following informal comparison trials the author conducted across prior projects. The reason is structural rather than a judgment of general capability. A tool optimized to synthesize an answer from ranked retrieval will produce an answer whenever ranked retrieval returns anything, and the present task depends on distinguishing three outcomes that such a tool tends to collapse into one: a document that appears not to exist, a document that exists behind a channel, and a determination that could not be made. An assistant asked whether a given manufacturer publishes cooling fan life will generally answer the question, and will less often report that the question has no public answer, which is precisely the report the absence classification requires. The exclusion rests on the author's own trials rather than on controlled benchmarking, no such benchmark was conducted for this work, and a reader reaching a different conclusion about those tools is disagreeing with a judgment rather than with a measurement.

Disclosure of AI Involvement

The disclosure literature has converged on the position that generative AI cannot hold authorship and that its contribution is therefore reported at the level of the task rather than declared in aggregate. Miessler (2023) proposed an AI Influence Level scale running from 0, human created with no AI involvement, through 5, AI created with little human involvement, with the label shifting from human created to AI created at level 3; Tolbert (2026a) adapted that scale for doctoral and graduate work. Suchikova et al. (2025) reasoned from a different starting point toward a compatible conclusion, proposing a delegation taxonomy in which the human specifies which discrete tasks were delegated instead of assigning a single global rating, and Wahle et al. (2023) built the same principle into a reporting card that separates methodology from writing and presentation. This report follows that convergence, since a single AIL figure would misdescribe work whose components were produced at different levels, and the aggregate would conceal precisely the distribution a reader needs.

Two features of that distribution warrant comment. Retrieval carries no AIL value because document location sits outside what the scale was constructed to measure. A literature review is not designated AI created for having run its search through Scopus, and the operative questions are whether the retrieved item was read, whether the claim traces to it, and whether an independent reader can verify the trace. Every document number, certificate number, and revision date in this report is published so that the third question has an answer available to anyone who wants one.

The prose sits at level 3, where the scale shifts its label from human created to AI created and treats that shift as a change in authorship rather than a gradation of degree. The standard Tolbert (2026a) applies to doctoral writing is stricter than what was applied here, and the

looser setting follows from what the work consists of, since the contribution lies in which documents were sought, how they were scored, which were excluded, and what the scoring passed over. Readers are entitled to that figure and to whatever weight they elect to place on it.

The Applicationist Contribution

The claim available here is narrower than the one commonly advanced on behalf of domain expertise, and its narrowness is what renders it defensible. The instruments demonstrated substantial competence with the subject matter, locating a TUV Rheinland certificate that two other instruments had independently declared nonexistent, an ABB functional safety document giving PFH by frame size and option code, a Toshiba wear-life table carrying four stated reference conditions, and a Japanese product page bearing on a rebadging question trade folklore has never settled. Several of those retrievals exceeded what a competent engineer would accomplish in comparable time.

What the instruments could not supply were the criteria. No search index contains the judgment that MTBF figures computed under Telcordia, MIL-HDBK-217, and IEC 61709 are not comparable to one another, and that silence on MTBF therefore constitutes a more honest disclosure than a number would. None contains the knowledge that specification writers routinely apply IEEE 519 at the drive terminals, which is what renders the 2022 scope note the most consequential finding in the technical leg. None weighs a missing fan life figure against a missing certificate according to which reader bears the cost of the omission. This is the applicationist contribution, the work of a practitioner who applies theory rather than generating it, and it operates at the level of what ought to be measured rather than what can be found.

The clearest evidence of that contribution in

this project is also the least flattering to it. The first pass followed documentation density rather than market presence, producing a technical leg weighted toward Danfoss, Vacon, Mitsubishi, and Toshiba while omitting Rockwell entirely, in both legs. No instrument identified the omission. The author identified it in a single sentence, because 27 brands of hands-on career history had established what the return should have contained and had not.

Positionality, Competing Interests, and the Limits of Adversarial Design

No non-disclosure agreement, non-compete, or privileged commercial information was employed in this work, and none was required, since every source cited is public and named. The author's situation nonetheless bears on the reading, and it is stated here rather than left for discovery. Thirty years in industrial controls and reliability, including hands-on work with 27 drive brands, supplies the criteria organizing this report and supplies whatever bias those criteria carry. The author is Senior Application Engineer and Director of Marketing at Malloy Electric, a distributor and service organization that carries **ABB, Toshiba, Fuji and SEW**. Two of those, ABB and Toshiba, hold the highest scores in this matrix, which makes this the disclosure that matters most in the document, and it is stated here rather than left for a reader to discover. Fuji appears only among the unscored lighter brands and SEW appears only in a chronology. Wayward Leaders LLC published and gates this report, and the commercial return on that gating is an email address.

Three things bound that conflict, and a reader should test all three rather than take any of them on assurance. The scores measure what each manufacturer chose to publish, which the author did not control and cannot influence, and every cell traces to a document number that anyone can pull. The rubric that produced the scores is published in full as Appendix B, so a reader who suspects the nine dimensions

were chosen to flatter a carried line can check that suspicion against the criteria directly. And the matrix is not uniformly kind to either brand: ABB scores 4 of 6 on operator reality and publishes nothing whatever about wear component life, while Toshiba scores 5 of 12 on compliance, the weakest showing among the top five. A scheme built to favor those two would not have produced those cells.

The interpretive stance taken here holds that rigor arises from making situatedness explicit and reflexively examined rather than from purifying interpretation of it. A practitioner carrying 30 years and 27 brands holds preferences, and a document denying as much would forfeit its credibility in the first paragraph. The productive question concerns what the design does about those preferences, and the answer divides along a line worth stating precisely.

Three instruments ran independently, without shared memory and without access to the author's priors, so that what the search returned was not conditioned on what the author expected it to return. They disagreed with one another and, on several cells, with him. A negative finding from any single instrument was treated throughout as a statement about one search rather than as a fact about the world, which addresses the specific failure to which a confident practitioner is most exposed. Evidence of that adversarial function appears in the document itself, where four cells on which the instruments disagreed are described in section 8.3 with the disagreement intact, and three of them resolved against the instrument that had declared an absence.

The design offers no comparable protection against the scheme. The author specified the nine dimensions, and three instruments applying those nine dimensions inherit whatever the dimensions value and whatever they pass over. Adversarial retrieval interrogates the evidence standing behind a cell, and it has nothing to say about whether the cell warranted existence in

the first place. A reader who concludes that the wrong properties were measured raises an objection this method cannot answer from inside itself, which is the reason the scoring scheme is published in full rather than summarized.

Errors, Omissions, and Why They Constitute Part of the Finding

This report contains omissions, and their presence carries more information than their absence would. The search design triangulates three independent frontier instruments against a scholarly harness running on an academic works index, declares its source ranks, excludes known-bad domains, and classifies every absence rather than assuming one. A routine of that construction, run against this subject, still returns gaps. Those gaps describe the state of the public record more than they describe a deficiency in the method, and the distinction governs how a reader should treat any particular missing cell.

Three categories of omission are anticipated here, and none of the three is correctable by searching harder. Material held behind a channel constitutes the largest. A manufacturer's reliability data residing in a distributor portal remains invisible to every instrument employed in this work regardless of how the prompt is written, which is the reason such cells carry the (b) classification rather than the (a). The second category comprises material that exists publicly and was not reached, since retrieval is probabilistic across instruments. The contested cells documented earlier demonstrate the mechanism from inside this project, where three of four resolved when one instrument produced a document that two others had independently declared nonexistent. That same failure operates at the boundary of the search, where no instrument produced the document and no disagreement flagged its absence, and those omissions are undetectable from within the design. The third category is instrument selection itself. The exclusion of retrieval-weighted

assistants described above removes whatever those tools would have contributed, plausibly including documents the retained instruments did not reach, and that exclusion was a judgment made for stated reasons rather than a neutral act.

A reader who locates a document this report treats as absent has therefore not refuted it, and a correction demonstrating that data sits behind a distributor login corroborates the central argument rather than undermining it, since the information existed and was not public. Corrections are welcome at carl@waywardleaders.com, and any subsequent edition will name what was corrected and who corrected it.

How to cite this edition

Tolbert, C. L. (2026). *The state of the VFD 2026: A public research and authority report* (Channel Edition). Wayward Leaders LLC.

Editions are triggered rather than scheduled, so cite the compile date printed on the first page along with the edition name.

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Appendix B: The scoring rubric

Published in full so that any cell in the matrix can be argued with. Nine dimensions in three families, each scored 0 to 3. Family A totals 12, Family B totals 9, Family C totals 6. The families are reported separately and never summed, because adding incommensurate dimensions manufactures a precision that is not there. A vendor can be strong on compliance and weak on operator access, and showing that is more useful than averaging it away.

Family A: Compliance and certification (12)

A1. Product cybersecurity certification. 3 = IEC 62443-4-2 product certificate with the number public, SL-C stated, and revision scope identified. 2 = certified with the body named, number not public. 1 = 62443-4-1 process certification only. 0 = intent statements or nothing.

A2. Efficiency documentation. 3 = IE class per IEC 61800-9-2 with loss data at the standard's operating points plus IES power drive system data, publicly accessible. 2 = IE class and loss data, no PDS data. 1 = IE2 compliance asserted, loss data not findable. 0 = nothing public.

A3. Functional safety functions. 3 = STO and SS1 in the base build of the general purpose family, SIL and PL stated against IEC 61800-5-2:2016, extended functions documented with option codes. 2 = STO base, SS1 by documented option. 1 = STO by option. 0 = not documented.

A4. Product safety listing currency. 3 = cited at edition, meaning IEC 61800-5-1 Ed 3.0 (2022), UL 61800-5-1 Ed 2 (2022), CSA C22.2 No. 61800-5-1:25. 2 = cited with editions partial. 1 = asserted without edition, or still citing the withdrawn CSA C22.2 No. 274. 0 = not findable.

Family B: Engineering evidence (9)

B1. Technical documentation depth. Publicly accessible without a login, at a stated revision. 3 = application guides at revision, harmonic data, cable length and dV/dt guidance with numbers, EMC category by configuration. 2 = most of that, some behind registration. 1 = datasheets and marketing only, engineering material behind a login or distributor channel. 0 = little public technical material.

B2. Reliability data published. Raw MTBF is deliberately excluded from the score. Published drive MTBF is calculated per Telcordia, MIL-HDBK-217 or IEC 61709 at a vendor-chosen temperature and load, and the same hardware yields numbers a factor of three apart by method. It is recorded where found, with its method and assumptions, and not scored. What is scored is the set of quantities the standards define identically for everyone. 3 = safety manual published with PFH, SFF, HFT, mission time and proof test interval for each claimed function, **and** wear component life at a stated ambient, meaning cooling fan L10 and DC link capacitor design life. 2 = safety reliability figures published, wear component life absent or qualitative only. 1 = SIL or PL claimed with no published PFH or SFF, or wear life stated without conditions. 0 = neither published. Recorded separately and unscored: stated design life, warranty term, and any published field return or failure rate data.

B3. Performance data published. Figures are comparable only when their conditions are stated, so the score is for stating them. 3 = overload capability given by duty class with

percentage, duration and duty cycle; derating curves published for ambient, altitude and carrier frequency; speed and torque control accuracy with the control mode and feedback arrangement named. 2 = overload and derating published, control accuracy absent or unconditioned. 1 = headline figures with no stated conditions. 0 = not published. A manufacturer quoting 200 percent overload without a duration scores 1.

Family C: Operator reality (6)

C1. Condition monitoring honesty. 3 = states per function which quantity is measured, which is modeled, and whether an external sensor is required. 2 = partial. 1 = capability claimed, physical basis not stated. 0 = marketing language only. This dimension inverts the usual reading. A manufacturer stating that its vibration monitoring requires accelerometers on 4 to 20 mA inputs scores high, because admitting the sensor requirement is disclosure. The low scores belong to anyone claiming bearing detection without saying what is measured.

C2. Commissioning and service access. 3 = complete parameter list published publicly; commissioning software free and downloadable without a login or service contract; firmware downloadable on the same terms; parameter backup and restore possible with the drive's own keypad or free software and no proprietary dongle; programming manual separate from the hardware manual, at a revision. 2 = most of that with one item behind registration. 1 = software or firmware requires a distributor relationship or paid account, or the parameter list exists only in gated documentation. 0 = little accessible without a channel relationship.

The rule that governs every cell

A low score means the evidence is not public. It does not mean the product is deficient. Rockwell's engineering material lives largely in its literature library and PCDC rather

than on crawlable pages. Siemens routes through SIOS and the Industry Mall. Those are disclosure postures rather than quality judgments, and without this rule the matrix would be unfair in a way a manufacturer could correctly object to.

Dimension	Leader	Evidence
Cybersecurity certificate	ABB	968/CSP 1036.00/25 with security level, dates, validity, firmware revision list, and honest treatment of which option modules are not independently certified
Efficiency documentation	Siemens	G120X generated data sheets publish IEC 61800-9-2 converter losses at standardized operating points, not merely the IE class
Functional safety functions	Eaton	DX1 published function by function: STO at SIL 3, PL e, Category 4; SS1, SLS, SSM and SBC to SIL 3, PL e, Category 3; SS2, SOS and SDI at SIL 2, PL c
Listing currency	no leader	Every brand checked still cites CSA No. 274 somewhere
Documentation depth	ABB and Toshiba	Revision-controlled PDFs, no login, document numbers visible
Reliability data	ABB for safety, Toshiba for wear life	No reviewed brand does both
Performance data	Toshiba	150% for 1 minute heavy duty and 120% for 1 minute normal duty, plus 180% for 2 seconds and 135% for 2 seconds; closed loop 0.01% at 1000:1, open loop 0.1% at 60:1; derating curves by frame against ambient and carrier; 1% per 100 m above 1000 m
Condition monitoring honesty	Danfoss and Toshiba	Danfoss names the 4-20 mA sensor requirement; Toshiba states it processes run time, load, temperature and output current and requires no external sensor
Commissioning access	Toshiba and AutomationDirect	Open manuals, register map, keypad transfer application note, free software

Table 3. Best in class by dimension, with the evidence each ranking rests on

Date	What happens
24 September 2026	Second EU ecodesign stakeholder meeting reported. Single source. Watch, do not plan
11 September 2026	Already live. CRA Article 14 reporting applies, including to installed product
1 June 2027	DOE efficiency cutoff on 100 to 250 HP motors. The retrofit band
Spring 2027	EU ecodesign review concludes. Commission adoption aim reported as 2029
Through 2027	Temporary capped 15% Section 232 tier for metal-intensive industrial and grid equipment. Drive coverage unconfirmed
1 September 2027	CSA transition from C22.2 No. 274 ends
11 December 2027	CRA full essential requirements and CE marking apply

Table 4. The regulatory calendar

Term	Meaning
AFE	Active front end
CRA	Cyber Resilience Act, Regulation (EU) 2024/2847
CSA	Canadian Standards Association
DC	Diagnostic coverage
FLA	Full load amperes
GaN	Gallium nitride
HFT	Hardware fault tolerance
HTSUS	Harmonized Tariff Schedule of the United States
IE2	Efficiency class for converters under IEC 61800-9-2
ISASecure	Conformance scheme operated by the ISA Security Compliance Institute
L10	Bearing life at 10 percent failure probability
MTBF	Mean time between failures
PCC	Point of common coupling
PFDavg	Average probability of dangerous failure on demand
PFH	Probability of dangerous failure per hour
PL	Performance level under ISO 13849
RUL	Remaining useful life
SCCR	Short circuit current rating
SFF	Safe failure fraction
SiC	Silicon carbide
SIL	Safety integrity level
SL-C	Security level capability under IEC 62443-4-2
SS1	Safe stop 1
STO	Safe torque off
THDi	Total harmonic current distortion
VFD	Variable frequency drive

Table 5. AI involvement by component, scored against the AI Influence Level scale

Component	AIL	Description
Research question and motivation	0	Author
CASINO design, scope areas, source ranking, excluded domains	0 to 1	Author, written and revised by hand
The nine-dimension scoring scheme	2	Author specified the dimensions and expanded them from cybersecurity alone to nine covering performance, published reliability figures, and usability; wording drafted with AI
Choice of deliverable form	0	Author. A scored matrix rather than a narrative
Retrieval and document location	not applicable	Instrumentation rather than authorship. See below
Conflict adjudication between instruments	2 to 3	Author set the standing rule that conflicts resolve on evidence and are never averaged; individual cells adjudicated with AI and reviewed
Vendor coverage and scope correction	0	Author. Identified a documentation-density bias in both legs that had overweighted several brands and omitted Rockwell entirely
Prose of this report	3	AI created, human full structure. The author supplied the structure, the argument, and the corrections; the sentences were drafted by the tool
Verification queue and published caveats	2	Author's standard, AI assembled

Table 6. Detail

About the author



Carl Lee Tolbert, PhD, CMRP, is a researcher and methodologist whose work bridges organizational leadership and industrial practice. He is Lecturer and Methodologist in the DBA program at Truett McConnell University, where he guides doctoral candidates through research design, instrument development, analysis, and defense, with additional faculty appointments at the University of Sioux Falls and Columbia International University.

He is an affiliated researcher with the Institute for Globally Distributed Open Research and Education, a peer reviewer for several MDPI journals, and is completing a Master of Arts in Technology and Society at the University of Chicago, examining how artificial intelligence reproduces the Enlightenment's quest for perfection.

His doctoral research was a hermeneutic study of industrial distribution drawing on interviews with more than 200 industrial leaders, and a follow-up study measured grit in more than 400 United States industrial maintenance workers, finding perseverance significantly above general-population norms and identifying newly promoted leaders as the highest burnout risk. He is the author of more than 20 peer-reviewed articles and chapters across leadership, organizational behavior, and applied engineering, and his books include *The 10 Immutable Laws of the Industrial Distribution Specialist* and *Before the First Fault*, a field treatment of variable frequency drive installation and reliability. His technical scholarship includes the ORCA research portfolio on drive reliability and remaining-useful-life estimation.

He holds a PhD in Organizational Leadership and the Certified Maintenance and Reliability Professional credential, and he is President of Wayward Leaders LLC in Sioux Falls, South Dakota.

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This report online: <https://waywardleaders.com/state-of-the-vfd-2026>

Courses and dates: <https://waywardleaders.com/training>

Field notes and fault references: <https://waywardleaders.com/field-notes>

Corrections to this report: carl@waywardleaders.com



Courses and dates

Compiled 14 September 2026 from public sources only. No manufacturer paid for placement, reviewed a draft, or was contacted during this work.