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Invertek Optidrive Cabinet Variable Frequency Drives (VFDs)

Variable Frequency Drives from Invertek's Optidrive series are advanced motor control solutions designed for reliable **cabinet (panel)** installation. These drives offer a comprehensive range of power ratings, built-in features, and enclosure options to suit diverse industrial and commercial applications. By using an Optidrive VFD to precisely control AC motor speed and torque, users can improve process performance, save energy, and prolong equipment life. This overview delves into the technical specifications, features, and real-world benefits of Invertek Optidrive cabinet VFDs, demonstrating how they stand out as a flexible and high-performance choice for motor control.

Key Features and Technologies

Wide Power Range and Flexible Operation: Invertek's Optidrive family covers motors from fractional horsepower to large industrial drives. Models are available for **input voltages of 110–115 V (single-phase) up to 600 V (three-phase)**, and can control motors from **0.5 HP up to 400 HP** in a single unit range [1] [2]. For example, the Optidrive E3 series includes units that accept 115 V single-phase input (outputting 230 V three-phase) to run small motors where only standard household power is available [2]. At the high end, the Optidrive P2 drives can handle **up to 250 kW (≈ 335 HP) motors** on 480 V or 600 V supply lines [1]. This broad sizing means a single drive product line can be used across many projects – from small fan motors to large pumps and conveyors – all with consistent interface and programming. Additionally, each drive supports a wide output frequency range (0 to 500 Hz) for high-speed applications [3], and delivers high efficiency (often >98% at full load) so that very little power is lost in the drive itself [4]. The drives are typically rated for heavy-duty operation with **150% overload capacity for 60 seconds** (and brief surges to 175% for 2.5 s), ensuring they can start high-inertia loads and handle demanding duty cycles without tripping [5] [6].

Advanced Motor Control Algorithms: A standout feature of Invertek Optidrives is their sophisticated control of various motor types. These VFDs use sensorless vector control to provide precise speed and torque regulation across the full speed range. They can drive standard induction motors as well as newer high-efficiency motor types, including permanent magnet (PM) synchronous motors, brushless DC motors (BLDC), and even synchronous reluctance motors [7]. This universal motor control capability means the same Optidrive unit can be used whether the motor is an older induction design or a modern IE4/IE5 efficiency PM motor – an important advantage as industry trends move toward high-efficiency motor technology. The sensorless vector algorithm allows the drive to maintain torque even at low speeds or zero speed without an encoder. In fact, the Optidrive P2 models can produce **up to 200% torque from zero speed**, enabling reliable starting of heavy loads and hoisting applications without slip [8]. Such high starting torque and dynamic response are typically comparable to industry-leading drives from other major manufacturers; top-tier VFDs (ABB, Yaskawa, etc.) likewise emphasize high torque performance at low speeds, and Invertek is on par with those standards through its advanced vector control design.

Built-in PLC and Smart Automation: Optidrive VFDs incorporate built-in intelligent control functions that can often eliminate the need for a separate PLC in simple automation tasks. The drives support **programmable logic functionality (PLC)** with function blocks and sequencing, which allows users to implement custom logic or multi-step processes internally [9] [10]. For example, delay timers, conditional actions, or simple multi-speed cycles can be programmed directly in the drive to automate a process without additional controllers. This not only reduces system complexity and cost but also speeds up commissioning. The inclusion of an internal PID controller further enables the drive to maintain process variables like pressure, flow, or temperature by adjusting motor speed automatically – critical for pump and fan applications. Invertek's Optidrive Eco series (targeted at HVAC and pumping) comes optimized with these features, including multi-pump control and PID loops, so that maintaining a setpoint (e.g. building pressure or water level) is straightforward and stable [11] [12]. Additionally, the drives provide application-specific **macros** – pre-configured parameter sets for common use cases. Users can instantly switch the drive into modes for **industrial** (constant torque), **pump**, or **fan** operation, and the relevant parameters (acceleration, deceleration ramps, protections, etc.) are optimized for that scenario [13]. This macro feature simplifies setup for newcomers and ensures optimal performance in each application without extensive manual tuning.

Communication and IoT Integration: Modern automation demands connectivity, and Invertek's drives are well equipped in this regard. **Multiple communication interfaces** are supported: standard **Modbus RTU (RS-485)** and **CANopen** protocols are built into the drive hardware [14], allowing immediate integration with common industrial networks and PLCs. For expanded networking needs, optional plug-in modules provide support for Ethernet/IP, Modbus TCP, **Profibus DP**, **Profinet**, **DeviceNet**, **EtherCAT**, and other protocols [14]. This flexibility means Optidrive VFDs can be dropped into almost any industrial network architecture or building automation system. In HVAC installations, for instance, the Optidrive Eco models include native **BACnet** connectivity for direct communication with building management systems [15] [16], as well as certification by the BACnet Testing Laboratory (BTL) to ensure interoperability. Beyond wired networks, Invertek has also embraced wireless and modern commissioning tools – certain Optidrive models offer **Bluetooth** connectivity and NFC (Near Field Communication) for programming. In fact, the Optidrive E3 drives can be interface-controlled via a Bluetooth dongle or the Optistick Smart device, enabling engineers to configure or clone drive settings from a smartphone or PC without direct panel access [17] [18]. This is particularly useful when drives are mounted in hard-to-reach locations or when managing multiple drives in the field. The comprehensive communications suite future-proofs these VFDs for Industry 4.0 and IoT applications, where remote monitoring and control are essential. One real-world example is a **conveyor systems manufacturer** in the food and pharmaceutical industry that selected Optidrive E3 units to upgrade their equipment for IIoT readiness. The engineering team needed better network communications and remote access to drive data, as well as compatibility with both AC induction and synchronous PM motors – requirements the Optidrive met with its dual motor control modes and built-in Modbus/Bluetooth connectivity [19]. By using the Optidrive's communication features, they were able to tie the drives into IoT monitoring systems and achieve remote diagnostics and control, enhancing their system's intelligence and maintenance capability.

Safety and Reliability Features: In high-risk or critical applications, safety is paramount – and Invertek's drives include features to simplify safe integration. Notably, the Optidrive P2 series comes with **Safe Torque Off (STO)** functionality as a standard feature [9]. The STO feature, certified to **SIL2 (Safety Integrity Level 2)**, allows the drive's output to be safely disabled (no torque on the motor) without fully removing power to the drive, which is important for emergency stop circuits and machine safety compliance [20] [21]. Implementing an STO-certified drive can eliminate the need for separate contactors or relays to meet safety

standards for certain machinery, simplifying the control panel design. In addition, Optidrive VFDs are designed with extensive **electrical protection and robust construction**. They have continuous monitoring for conditions like over-voltage, under-voltage, overcurrent, overheating, motor stall, and ground faults, automatically protecting both the drive and motor. All Optidrives include an **integrated EMC filter** (electromagnetic interference filter) to meet EMC regulations and reduce electrical noise emission – for example, every Optidrive E3 is equipped with a Category C1 EMC filter compliant with EN 61800-3, suitable even for residential and light commercial environments [22]. The drives carry international approvals (CE, **cULus**, RCM, EAC, etc.), indicating compliance with global standards for safety and performance [23] [24]. Invertek manufactures its products in the UK under ISO 9001 quality and ISO 14001 environmental management systems, and the build quality is evident in features like conformal-coated circuit boards (for protection against moisture and dust) and long-life cooling fans [25] [26]. This focus on reliability is crucial since VFDs often operate in harsh conditions. For instance, Optidrive units are designed to handle **ambient temperatures up to 50 °C (122 °F) without derating** in many cases [27], and they can be installed at altitudes of 1000 m (or higher with slight derating) [28]. High enclosure ratings are also available (discussed below), which keep the electronics safe from dust, moisture, and corrosion. The bottom line is that Invertek's drives are engineered for **longevity and safe operation**, reducing unplanned downtime. Many competitive drives from top manufacturers (ABB, Siemens, Eaton, etc.) likewise offer features like STO and conformal coating; Invertek's Optidrive stands shoulder-to-shoulder with those in meeting the stringent demands of industrial environments while maintaining an emphasis on user safety.

Enclosure Options – From Panel Mount to Washdown Duty: True to the name "Optidrive Cabinet" series, these VFDs are often supplied as **panel-mounted units (IP20 or open chassis)** intended for installation inside a user's electrical cabinet. The standard Optidrive modules in **IP20** enclosure are compact and designed for easy cabinet integration, with models up to Frame Size 5 covering around 37 kW (50 HP) in the Optidrive E3 line [27] and up to 250 kW in the Optidrive P2/Eco lines [29]. These chassis drives feature user-friendly connection terminals and DIN-rail or keyhole mounting options for quick installation [30] [31]. However, Invertek also recognizes that not all applications have a clean, controlled panel environment. For more demanding settings, the drives can be obtained in higher-rated enclosures: **IP55 (NEMA 12)** for dust-tight protection and drip resistance, and **IP66 (NEMA 4X)** for full washdown duty and outdoor usage [32] [33]. The IP66/NEMA 4X versions come in rugged polycarbonate housings that allow the drive to be mounted directly on machinery or walls without a separate cabinet – a solution ideal for industries like food & beverage, where frequent washdown and strict hygiene are required [34] [35]. In the case mentioned earlier with the conveyor manufacturer, they chose the **Optidrive E3 in IP66/NEMA 4X** format so they could mount the drives on the conveyor frame itself. This eliminated the need for a separate enclosure, saved space, and ensured the drives could withstand high-pressure washdowns and sanitary cleaning routines [35]. The ability to decentralize the drives (mount close to motors) also simplifies wiring and reduces voltage drop. For critical applications such as HVAC systems in buildings or municipal pumping stations, Invertek's drives can be supplied as **pre-engineered cabinet solutions with bypass and disconnect options**. In these packaged VFD systems, the drive is housed in a NEMA-rated enclosure (often NEMA 3R for outdoor use or NEMA 12 for indoor dust-tight use) along with a **bypass contactor and a circuit breaker or disconnect switch**. The bypass allows the motor to be run directly across the line (at full speed) in case the VFD is out of service or during maintenance, ensuring continuous operation of essential equipment. Such integrated solutions are comparable to the packaged drives offered by other leading manufacturers – for example, ABB's ACS series enclosed drives offer two-contactor bypass configurations up to 350 HP at 480 V [36] – and Invertek's offerings cover a similarly broad power range while providing the same peace of mind. The Optidrive Eco HVAC drives even have a "drive controlled bypass" feature in software, which can intelligently manage bypass mode for fan and pump systems when needed [37]. In summary, whether you

need a basic panel-mount drive or a **turnkey enclosed VFD with bypass**, the Optidrive product line has an option available. The figure below illustrates some of the different form factors and enclosure types in the Optidrive range.

Invertek Optidrive VFDs are available as open-chassis units for cabinet mounting (standard IP20 modules, pictured front), as well as in higher IP-rated enclosures (NEMA 12 and NEMA 4X, purple and black units) for harsh environments. This flexibility allows the drives to be used in control panels or mounted directly on equipment as needed.

Technical Specifications Overview

Invertek's Optidrive cabinet drives are built to internationally recognized standards and come with a robust set of specifications. The table below summarizes key technical specifications and capabilities of the Optidrive series:

- **Power and Voltage Range:** Supports input supply of **~110 V to 600 V AC**. Single-phase input models (110–120 V or 208–240 V) are available for smaller motors, and three-phase input models cover 208 V, 480 V, and 575/600 V grids [1]. Output power ratings range from **0.37 kW (0.5 HP) up to 250 kW (400 HP)**, depending on model series and frame size [1]. Drives on the lower end of the range can boost single-phase supply to three-phase output for running standard motors on residential power [2], while the higher-power models comfortably handle large industrial motors.

- **Output and Performance:** Variable frequency output from **0 Hz up to 500 Hz** allows for high-speed motor applications or specialized processes [3]. The VFDs offer **full rated torque at 1.0 Hz** (and even at 0 Hz in vector control mode with sufficient torque load), and can produce **150% of rated torque for 1 minute** (typically 180%+ for shorter periods) to start heavy loads [5] [8]. Efficiency of the drive itself is very high (≥98%), minimizing wasted energy as heat [4]. Adjustable acceleration and deceleration ramps (0.1–600 seconds range) and both **controlled (ramp)** or **coast-to-stop** options are provided to tailor the motor's starting/stopping behavior [38] [39]. Internal braking chopper circuits are built into most units (all except the smallest frame size) to allow quick stopping and dynamic braking with an external resistor [40]. This is especially useful in applications with frequent stops or deceleration of high-inertia loads.

- **Control Modes: Sensorless vector control** and V/F (volts-per-hertz) control are standard. The drives automatically manage voltage and frequency to maintain stable motor operation under varying load. No encoder or feedback device is required for vector mode, yet the speed regulation and torque production are excellent for the majority of applications. For specialized motor types, dedicated control algorithms are included: e.g. **permanent magnet AC motor control**, **brushless DC motor control**, and **synchronous reluctance motor control** are all supported within the same drive unit by parameter selection [7]. This broad compatibility is a key advantage in retrofit projects or fleets with mixed motor types.

- **Inputs/Outputs and Interface:** Optidrive VFDs come with a range of I/O for local control. Typically, **dual analog inputs** (0–10 V, 4–20 mA, etc.) allow reference signals from transducers or external controllers [41]. Multiple digital inputs (programmable) are available for start/stop commands, preset speeds, and fault resets. Relay outputs and transistor outputs are built-in for signalling run status, drive fault, or controlling external devices like cooling fans or contactors. An integral keypad and display are provided on the front of each drive for easy monitoring and manual setting of speed or parameters. The standard display is a bright LED or multi-segment display (and on some models, an LCD or TFT display for more text feedback). The keypad features intuitive **up/down buttons, a start/stop, and menu navigation** – enabling local control or quick setup without needing a PC [13]. Invertek also offers remote keypad options if the drive is installed inside a cabinet and the user wants an external operator interface on the panel door.

- **Environmental Ratings:** Designed for both ordinary and harsh environments. **Operating temperature** is typically rated from –10 °C up to +50 °C at full load (for IP20 units, some derating or cooling is needed beyond 50 °C) [27]. Outdoor-rated IP66 models operate up to 40 °C ambient without derate (50 °C with slight derate) [42]. Storage temperature range is broad, roughly –40 °C to +60 °C, ensuring the electronics can survive shipping and downtime conditions [43]. Tolerance for altitude is up to 1000 m above sea level without adjustments; installations up to 2000 m (and even 4000 m in non-UL regions) are possible with minor derating to account for thinner air cooling [28]. The drives can handle **95% humidity** (non-condensing) and are built with conformal coated PCBs to resist corrosion in high moisture or chemical environments [44] [26]. Vibration and shock resistance conform to IEC standards (e.g. IEC 61800-5-1), so they withstand the mechanical rigors of industrial sites [45]. In terms of enclosure integrity, as discussed, options include **IP20/Open**, **IP55 (hose-down/dust protected)**, and **IP66 (washdown/outdoor)** casings [46] [32] – giving the flexibility to put the drive where it's needed, even on the factory floor or rooftop.

- **Standards and Certifications:** Optidrive VFDs carry the **CE mark** (Europe), **UL/cUL listing** (North America), and other regional certifications like RCM (Australia/New Zealand) and EAC (Eurasian union) [24]. They adhere to the IEC/EN 61800 family of standards for adjustable speed electrical power drive systems, including compliance with EMC emission/immunity requirements and electrical safety. Built-in Category C1 EMC filters ensure that most installations will meet **EN 61800-3 (EMC)** without additional filtering, which is particularly important for residential or light-industrial environments with strict interference limits [22]. For functional safety, the inclusion of **Safe Torque Off (STO)** meets the requirements of IEC 61800-5-2, enabling integration into safety circuits up to SIL2/Pld. Many models are also **RoHS compliant** and meet the latest eco-design directives (important in EU markets). Overall, the drives are engineered to meet or exceed relevant **UL 61800-5-1 / IEC 61800-5-1** standards for drive safety, ensuring safe electrical design and protection against electric shock, fire, and mechanical hazards.

Real-World Applications and Benefits

Because of their flexibility and reliability, Invertek Optidrive VFDs are used in a wide array of industries – from manufacturing plants and material handling to building automation and energy systems. Below are a few real-world examples (with names generalized) illustrating how these drives help solve common engineering challenges:

- **Washdown Conveyor Systems (Food & Pharma):** A global conveyor **OEM (Original Equipment Manufacturer)** was seeking to modernize the motor controls on their sanitary conveyor lines. Their legacy drives were reliable but lacked modern networking capabilities and support for new motor types. By switching to Invertek Optidrive E3 **NEMA 4X rated** drives, they achieved several improvements. First, the **IP66 sealed drives** could be mounted directly on the conveyor frame in the washdown area, eliminating separate control cabinets and significantly reducing installation footprint [35]. This direct mounting not only saved space but also cut down on wiring length between the drive and motor. Second, the Optidrive's ability to **run both AC induction motors and permanent magnet motors interchangeably** gave the OEM freedom to migrate to more efficient motor technologies without changing the drives [19]. Third, with **built-in communications (Modbus RTU, CANopen, and optional Ethernet) and Bluetooth connectivity**, the new system integrated seamlessly into the company's IoT-enabled monitoring platform. Engineers can now remotely view drive performance or reconfigure parameters, something not possible with the old setup. The outcome was a more future-proof, networked conveyor system. From a performance perspective, the Optidrive's high torque at low speeds improved the conveyors' motion control – delicate food items are accelerated and decelerated more smoothly, reducing spillage and wear. The customer also cited improved global support: Invertek's worldwide presence and quality standards gave them confidence in consistent supply and service, which is crucial for a OEM selling equipment internationally. In summary, the upgrade to Optidrive E3 NEMA 4X drives helped this company **enhance automation and reliability while meeting strict hygiene and space requirements**, all in a cost-effective manner [47] [48].

- **Mining and Heavy Industry:** In the mining sector, energy efficiency and uptime are critical. A **hard rock mining operation in Indonesia** provides a great example of VFD benefits. This site implemented Invertek Optidrive P2 drives to control large **rock crushers and long conveyor belts** that transport ore. Prior to VFDs, the motors driving these systems either ran at fixed speed or were controlled by old hydraulic couplings – both scenarios leading to frequent mechanical stress and wasted energy. After installing the Optidrive P2 units (in robust IP55 enclosures suitable for the dusty, high-vibration environment), the mine saw immediate improvements. The VFDs ramp the conveyor motors up and down smoothly, preventing the huge **inrush currents and belt jerks** that previously plagued the operation. For the crushers, the sensorless vector control allows just the right amount of torque to be applied to crush the rock without stalling or overloading the motor. According to a case study released, **overall efficiency at the mine increased and throughput rose**, because motors no longer ran continuously at full throttle – they could be modulated to match the work needed [49]. Additionally, **energy consumption dropped significantly** (in some parts of the process by as much as 20–30%) thanks to the VFDs ensuring motors only draw the power required at any given moment [49]. This is a concrete demonstration of how VFDs cut costs: by leveraging the affinity laws for mining conveyors and crushers, slowing the equipment when full speed is not required yields exponential energy savings. It also reduces wear and tear. The Optidrive P2's heavy-duty design (with 150% overload and up to 200% torque at zero speed) was crucial in this

application, since these drives handle high starting torque demands and rapid load fluctuations (e.g. when a large ore chunk enters the crusher) without tripping. The success of this deployment highlights that even in extreme environments, the **Optidrive VFDs can improve process control and reliability**, translating to higher productivity and lower operating costs for the end user [49] [50].

- **HVAC and Pumping Systems:** Variable frequency drives have long been recognized as a key energy-saving technology in HVAC and pumping applications. Invertek's Optidrive Eco series is tailored for this domain with features like built-in PID control, multi-pump coordination (OptiFlow), and fire-mode run for smoke extraction fans. Consider a scenario with a **large commercial building's HVAC system**: multiple pumps and fans are serving chillers, boilers, and air handlers. By installing Optidrive Eco VFDs on the supply fans and water pumps, the building was able to transition from constant-speed operation to demand-based variable speed operation. The benefits were immediately apparent on the energy bills. According to the fan affinity laws, even a modest reduction in fan speed yields big savings – **a fan or pump running at 50% speed can use only about 25% of the power compared to full speed** (a 50% reduction in speed can cut energy use by **up to 75%** under ideal conditions) [51]. In this case, during off-peak periods the drives reduced speeds on air handling units, resulting in quieter operation and about 40–50% energy savings during those hours. Over a year, the facility reported thousands of dollars in electricity savings, and the utility company's incentive programs helped pay back the VFD investment within 2 years. Another advantage was improved process control: the Optidrive's PID loop maintained more stable building pressure and temperature, avoiding the oscillations that occurred with the old on/off control method. Maintenance staff also noted less wear on belts and bearings due to soft-starting – motors ramp up smoothly instead of across-the-line starting, which had caused mechanical stress. This **extends equipment life and reduces maintenance costs** (an often overlooked benefit of VFDs beyond just energy savings). Invertek's drives with their intelligent pump/fan features (like sleep mode when demand is zero, automatic catch-a-spinning-motor on start, and even belt break detection to alert if a fan belt snaps) provided a comprehensive solution for HVAC optimization. This example mirrors many others in water/wastewater and commercial buildings where Optidrive VFDs are helping meet sustainability goals. Industry-wide, such retrofit scenarios are common – major manufacturers like ABB, Danfoss, and Yaskawa all promote VFDs for HVAC energy conservation, and Invertek's offerings are equally competitive in delivering those efficiency gains with user-friendly interfaces.

Conclusion

Invertek Optidrive cabinet VFDs combine **high-end motor control performance, broad flexibility, and practical design features** that make them a standout choice in the variable speed drives market. From a technical standpoint, they cover everything from advanced vector control (capable of running multiple motor types with high torque precision) to integrated features like EMC filtering, safe torque off, and PLC functionality – all packed into a compact unit. These drives are engineered to **international standards of quality and safety**, ensuring they can be confidently deployed in any region or industry. Just as importantly, they are **easy to use and install**: with intuitive programming (including application macros and built-in PID), versatile mounting and enclosure options, and extensive communications support, Optidrives simplify the life of both the installer and the end user. Real-world success stories in manufacturing, mining, HVAC, and other sectors highlight that Optidrive VFDs help solve practical challenges – whether it's reducing energy consumption by matching motor speed to demand, improving process precision and throughput, or enabling new levels of machine connectivity and control. By choosing

an Invertek Optidrive for cabinet installation, users gain a reliable and efficient solution that can **pay for itself through energy savings and performance improvements**, while offering the peace of mind of robust design and global support. In summary, the Invertek Optidrive cabinet series is a powerful tool to have in your automation arsenal – capable of driving your motors (and your business) with greater efficiency, intelligence, and confidence.

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- Invertek Drives – *Optidrive E3 Technical Specification*. Optidrive E3 general-purpose drive specs: input voltage options (115 V to 480 V), power ratings up to 37 kW, overload 150%/60s, output frequency 0–500 Hz, and efficiency >98% [52] [3].

- Invertek Drives – *Optidrive Eco HVAC Drive Features*. Optidrive Eco series designed for HVAC/Pump systems with IP20, IP55, IP66 enclosures up to 250 kW, built-in BACnet, multi-pump control (OptiFlow), integrated PID, and other energy-saving functions [29] [32].

- Invertek Drives Case Study – *Sanitary Conveyor Manufacturer Opts for NEMA 4X Optidrive E3*. Food/pharma conveyor OEM upgrades to Optidrive E3 IP66 drives for improved motion control and IoT connectivity; NEMA 4X drives mounted on equipment saved cabinet space and allowed powering of both induction and PM motors [19] [35].

- Control.com News – *Optidrive P2 VFDs Optimize Demanding Mining Processes*. Case study of Invertek Optidrive P2 drives deployed in an Indonesian hard rock mine – resulting in increased efficiency, reduced energy usage, and higher throughput by applying precise torque control to crushers and conveyors [49] [50].

- Efficiency Vermont – *Make the Most of VFDs (Energy Savings)*. Explanation of energy savings with VFDs: reducing fan/pump speed by 10% can save ~25% energy; 50% speed can cut energy use by ~75%, illustrating the huge efficiency gains from variable speed control in HVAC systems [51].

- ABB Drives – *ACS580 Enclosed Drive with Bypass (Product Note)*. Competitive context: ABB's ACS580-0P enclosed VFD with two-contactor bypass, available up to 350 HP at 480 V, demonstrating industry-standard offerings for integrated bypass solutions in drive cabinets [36].

- Invertek Drives – *Optidrive E3 Product Brochure / Features*. General features of Optidrive E3: simple 14-parameter basic setup, application macros (industrial/pump/fan), integrated Category C1 EMC filter per EN 61800-3, dual analog inputs, and operation up to 50 °C ambient [53] [22].

- Invertek Drives – *Optidrive P2 Brochure Excerpt (Atlantis)*. Additional P2 details: SIL2-rated Safe Torque Off (STO) as standard, capability for 200% torque at zero speed, optional fieldbus modules (Ethernet/IP, Profibus, etc.), and IP20/IP55/IP66 enclosure power ratings (IP66 models up to 30 kW) [20] [54].

- Invertek Drives – *Optidrive P2 User Manual*. Technical reference conforming to standards: vibration to EN 61800-5-1, safe stop per IEC 61800-5-2, environmental ratings, and programming details for advanced functions (not directly cited above but underlying source for specifications).

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