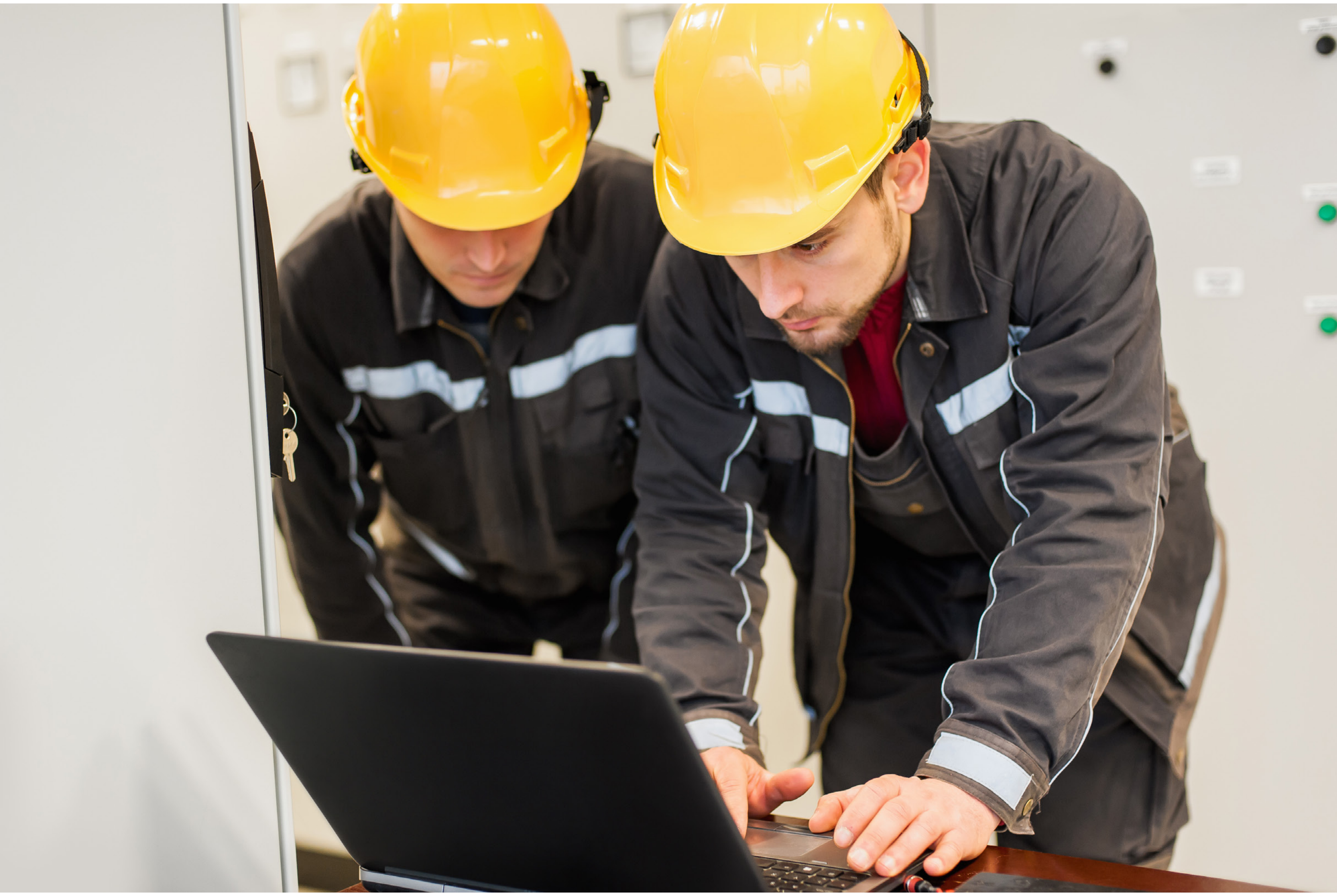
ASSET MANAGEMENT STRATEGY

Rethink Automatic Transfer Switch specs: Improve reliability and reduce maintenance costs with advanced condition monitoring technology



Introduction

An Automatic Transfer Switch (ATS) is a device to automatically switch electrical loads from a primary power source to a secondary source (like a generator) if the primary power source fails. As part of an Emergency Power Supply System (EPSS) the purpose of the ATS is to ensure continuity for all types of electrical loads. Within critical infrastructure facilities such as data centers and hospitals this means the EPSS is protecting 24/7 processes and data integrity as well as equipment that maintains and saves human lives.

Traditional ATS design specs assume that facilities will follow a time-based, preventative strategy of periodic visible inspections, maintenance, and testing to maintain these devices. Unfortunately, because it is necessary to power down the EPSS to perform preventative maintenance, many facilities fail to follow these guidelines, especially if redundancy was not initially designed into their system, plus it takes significant effort and coordination to schedule a maintenance window. By waiting for an ATS to fail before attempting to perform maintenance, facilities leave themselves vulnerable to an expensive power outage.

Despite its paramountcy in the EPSS, traditional ATS designs have not incorporated the predictive maintenance advances of today's digital monitoring and Industrial Internet of Technologies (IIoT) that will alert facility managers to potential asset health issues that impact device performance. Fortunately, new ATS design now makes this possible; but realizing the benefits of advanced condition monitoring starts by facility managers and engineers rethinking their ATS design specifications.

"Almost all downtime results from planning and investment decisions, coupled with poor processes or a failure to follow processes. They may therefore be termed management failures."

Andy Lawrence, Executive Director of Research
Uptime Institute
Source: Uptime Institute Research, June 2018

Typical ATS failures

An ATS is expected to last 20-25 years with best practices calling for replacement before they experience full failure[1]. However, a 2013 survey by Building Operating Management magazine discovered that 25 percent of the units were less than five years old when they failed, the same percentage reported for units age 15 or more[2]. Obviously the longevity and viability of ATS varies greatly depending on the application and general health of each device. Some devices may sit in stand-by mode for years without cycling, while others may be called upon to switch power multiple times a month. Understanding the condition of each unit is key to optimizing performance and preventing a failure that could lead to a power outage.

According to Brad Wieskus, Field Service Engineer for ABB, the three most common causes of ATS failure can be attributed to a lack of regular cycling, component failure related to lack of maintenance, and the big one: human error. “When you walk into a facility that had a recent ATS failure, it is probably a facility that either hasn’t been testing or trained its personnel on proper ATS maintenance protocols — or both.”

Typically, when an ATS fails to switch to the backup power source as intended, the cause can be attributed to failure with its mechanism (solenoid/motor), power electronics, circuit fault/overload, excessive contact wear, or a build-up of corrosive materials on the electrical contacts within the switch. Humidity, contact materials, environmental gases and other pollutants can all affect contact corrosion. In traditionally designed ATS units that are not subject to periodic maintenance and testing beyond initial commissioning, the switch can sit in its normal standby mode without ever cycling, then malfunction during an actual power interruption, resulting in an outage.

The 2019 National Fire Protection Association published standard for emergency and standby power systems (NFPA® 110) recommends that facilities develop and maintain a written schedule for routine maintenance and operational testing of the EPSS. Further, it indicates that transfer switches should be subjected to a maintenance and testing program that includes checking of all connections, inspection or testing for evidence of overheating and excessive contact erosion, removal of dust and dirt, and replacement of contacts when required.

“I know of an airport that didn’t design redundancy systems on the front end and as a result, they had not performed maintenance on their ATS in over ten years,” Wieskus said. “Unfortunately, one of their ten switch banks had fallen out of calibration over time so when a storm knocked out the primary power and the transfer to backup was needed, the system failed and they lost their outside lights for a couple of hours.”

According to Andy Lawrence, Executive Director of Research for the Uptime Institute that tracks risk and resiliency in data centers, “it is rare that the initial cause of a problem is contained, so a power problem may soon become an IT systems recovery issue, especially where multiple, interdependent databases are affected, as is usually the case.” He points to human error as the primary culprit, citing a June 2018 Uptime Institute research study that reported a staggering 80% of the survey respondents as saying their most recent power outage could have been prevented.

"In our experience," Lawrence said, "almost all downtime results from planning and investment decisions, coupled with poor processes or a failure to follow processes. They may therefore be termed management failures."

This same Uptime Institute research study points to power outages as the top cause of big, public data center failures since early 2016. It found that power outages accounted for 36 percent of data center failures, followed by 25 percent for network issues and 22 percent for IT/software issues. Forty-one survey respondents reported outage costs exceeding $1 million. One outage cost over $50 million. Around a third of all reported outages cost more than $250,000.[3]

One hour without power in hospitals is estimated to cost more than $100,000, and that doesn't factor in the impact these events can have on patient care and safety.[4] Exacerbating the problem with power outages is the fact that modern healthcare IT equipment is even more sensitive to electrical disturbances than in the past and, at the same time, more important to patient care than ever before. As a result, increasingly hospital IT personnel are demanding the ability to monitor and control power, raising an expectation for better data about EPSS performance capabilities.

Clearly hospitals, data centers and other critical infrastructure facilities need an ATS design that enable a smarter, more proactive asset health approach.

How ATS design impacts asset health strategy and maintenance protocols

Typically, facilities specify ATS engineering designs that include “visible/replaceable contacts” to support a time-based preventative maintenance strategy. Unfortunately, the preventative maintenance protocol also has downsides. It does not eliminate the risk of unit failure between scheduled service intervals. Nor does it eliminate the risk of maintenance precision issues. Plus, replacement parts can be both costly and difficult to acquire in a timely manner. But even if parts are purchased in advance, replacing the ATS altogether could be more desirable than replacing worn or faulty electrical contacts just to protect management’s peace of mind, especially when the unit is older and/or cycles power frequently.

There is a better way. Shifting from an ATS design specification of “visible/replaceable contacts” to a design spec that utilizes built-in advanced condition monitoring enables facilities to reduce downtime, minimize maintenance precision issues, and save costs. Instead of having to depend entirely on periodic human inspections and component repairs to do preventative maintenance, operators get actionable, data-based intelligence that supports more reliable predictive maintenance protocols.

By now, the promise of condition monitoring on critical power distribution assets is well known: reduced capex, longer asset life, avoided unplanned shutdowns, improved safety, and a substantial reduction in maintenance spending. All of which adds up to reduced costs and greater reliability over time because of better asset management. Capturing operational and condition data also provides facility managers intelligence to identify and head off potential problems.

“With strategies including predictive and preventative maintenance in place, the potential for system failure is considerably reduced,” said Robert McClary, Chief Operating Officer, FORTRUST, the only collocation data center in the United States certified Tier III Gold by the Uptime Institute[5].

Comparing ATS maintenance strategies

Strategy/Definition	Pluses	Drawbacks
Corrective (Event-Based) *Assets are run to failure then fixed or replaced when broken*	- Maintenance resources (time and money) allocated solely on damaged assets or systems.	- High risk of power outage and/or damage to other equipment in the EPSS. - Requires costly redundant EPSS design to minimize risk.
Preventative (Time-Based) *Scheduled asset inspection and maintenance at pre-defined, timed intervals*	- May identify and fix issues before the asset breaks.	- Opening the ATS cabinet door to visibly inspect contacts and perform maintenance introduces an arc flash safety risk. - Visible inspections are both subjective and subject to human error - Should the ATS develop a problem between inspections/maintenance there is a risk of asset failure and power outage. - Necessary parts may be difficult to locate or unavailable. - Planned system downtime necessary to perform maintenance. Best with redundancy system design. - Minimizes possible precision maintenance errors that may be otherwise be introduced if procedures not appropriately followed.
Predictive (Asset-Based) *Data-driven inspection and maintenance or replacement Based on environment conditions measurement & analysis (model based) and/or actual asset health and performance by direct measurement of equipment or process*	- Maximizes uptime & asset longevity. - Minimizes opportunity for subjective human error and unnecessary safety issues (arc flash). - Alerts of worn components and other performance issues enable repair or replacement before unexpected failure.	- Rare sensor or communication malfunction. - Statistical outlier event missed by algorithm.

The business case for a different ATS asset management approach

Until ABB launched TruONE™ [Figure 02] - an all-new automatic transfer switch with built-in controls, connectivity and advanced sensing including voltage, current, and temperature - real time condition monitoring of critical components was not possible in a typical ATS. Critical parameters such as overload transfers or temperature can be monitored directly. Further, contact wear life %, can be modeled during the duration of the switch's life using testing-backed algorithms. Its game-changing impact for transfer switch users was recently recognized by Frost & Sullivan with its 2019 global *New Product Innovation Award*.

Each year, this award recognizes a company for innovations that provides customers value-added features/benefits and an increased return on investment (ROI). In presenting this award, Frost & Sullivan cited TruONE™'s ability to offer predictive analytics and condition monitoring capabilities for automatic transfer switches that provide improved overall reliability, safety, and efficiency of operations. Additionally, Frost & Sullivan noted that its modular, self-contained design with enclosed electrical contacts makes configuration and maintenance easier and safer.

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02 The ABB TruONE™, the engine that now drives the Zenith ZTG T-series.

With ABB's acquisition of GE Industrial Solutions, the company is now combining its award-winning TruONE™ modular ATS technology with GE's time-tested Zenith ATS family [Figure 03.] With the all-new Zenith ZTS T-series, facility managers and engineers can now rewrite their asset management playbook to get all the necessary sensors, controllers, switches and operator interfaces in a self-contained ATS unit that supports advanced condition monitoring and predicts the end-of-life of the asset. [Figure 04.]

Electrical contact wear is continuously computed using an empirically tested algorithm derived from load current and switching data that is more reliable than reliance on purely periodic (annual) visual inspections and maintenance. Similarly, the Zenith ZTS T-series' built-in, real-time temperature monitoring adds another layer of protection for added confidence in the health and functionality of all cable connections to the controller, sensing panels and other system components.

Conversely, ATS units without advanced condition monitoring capabilities typically require maintenance technicians to remove arc chutes and pole covers periodically to allow visible inspection of the main arcing and main current contacts for excessive wear, pitting and/or corrosion. Plus, when ATS wear has degraded to a level that contact replacement is necessary, spare parts prices and labor costs are not insignificant. Worse, these costs do not include the potential damage of other components. Highly subjective by nature, even if the ATS design has a transparent window for viewing the electrical contacts, this practice is prone to human error. There is no industry standard that defines what technicians should look for or how they should be trained to conduct inspections. Obvious signs like burning and discoloration are probably far too late for preventative remediation as at this point other system components have likely already been damaged. Plus, it is not uncommon for humans to introduce issues during the maintenance process.

See Figure 5 for a top-line summary of how the built-in advanced condition monitoring features in the Zenith ZTS T-series addresses NFPA® 110 transfer switch maintenance and operational testing program guidelines. For a more detailed, step-by-step comparison, see Figure 6.

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03 ABB Zenith ZTS family series.

04 Zenith ZTS T-series family.

Product	ZTS		ZBTS	
Type	Standard ATS for mission critical, data center, and healthcare		Maintenance bypass ATS for mission critical, data center, and healthcare	
Controls	Color touchscreen HMI with predictive mainteance, programmable/expandable IO, advanced communications, and ABB Ability™ - ready for remote monitoring and active alerts			
Rating Transition	30-1200A: Open, Delayed	1600-3000A : Open, Delayed 400-3000A: Closed	30-1200A: Open, Delayed	1600-3000A: Open, Delayed 1000-1600A: Closed
Max withstand	65kA, 0.05s @480Vac WCR 50kA, 0.50s @480Vac STR	100kA, 0.05s @480Vac WCR 65kA, 0.50s @480Vac STR	65kA, 0.05s @480Vac WCR 50kA, 0.50s @480Vac STR	100kA, 0.05s @480Vac WCR 65kA, 0.50s @480Vac STR
Design type	Modular all-in-one ATS powered by TruONE™	Traditional power contactor ATS with TruCONTROL	Modular all-in-one ATS powered by TruONE™	Traditional power contactor ATS with TruCONTROL
Advanced condition monitoring features	- Modeled contact wear & prediction - Overload transfer statistic monitoring - Temperature sensing - Local alarms - ABB Ability capable for custom alerts	- Overload transfer statistic monitoring - Temperature sensing - Local alarms - ABB Ability capable for custom alerts	- Modeled contact wear & prediction - Overload transfer statistic monitoring - Temperature sensing - Local alarms - ABB Ability capable for custom alerts	- Overload transfer statistic monitoring - Temperature sensing - Local alarms - ABB Ability capable for custom alerts
Additional unique benefits	- Modular communication - Quick swapable HMI - No line voltage connections to door - Fast mechanism/ switch, replacement - Enclosed self-cleaning contacts	- Modular communication - Quick swapable HMI - No line voltage connections to door	- Modular communication - Quick swapable HMI - No line voltage connections to door - Fast mechanism/ switch, replacement - Enclosed self-cleaning contacts	- Modular communication - Quick swapable HMI - No line voltage connections to door

05 Overview of NFPA® 110 Transfer Switch Maintenance and Operational Testing Program for Zenith ZTS T-series.

- **NFPA** 8.3 Maintenance and Operational Testing.
- **NFPA** 8.3.4* Transfer switches shall be subjected to a maintenance and testing program that includes all the following operations:

Program operations	ZTS T-series feature	Benefit	Value
Checking of connections	Advanced condition monitoring: temperature monitoring	Reduce the need for physically checking connections with constant measurement at power poles while providing alerts when high temps occur.	- Simplify & reduce inspection time. Peace of mind (alerts).
Inspection or testing for evidence of overheating and excessive contact erosion	Advanced condition monitoring: modeled contact wear, temperature monitoring	Simplify NFPA 110 required contact erosion inspection by providing modeled contact wear on HMI. Reduced dependency on subjective visual inspection. Alarm to dangerous conditions 24/7 in between inspection intervals.	- Simplify & reduce inspection time. - Minimize maintenance precision issues. - Reduce safety risk. - Peace of mind (alerts).
Removal of dust and dirt	Enclosed contacts (1200A and below)	Contacts are fully enclosed, reducing foreign dirt and dust ingress, while self-cleaning knife contact design maintains consistent contact quality.	- Eliminate maintenance precision issues.
Replacement of contacts when required	Complete ATS replacement Contact replacement otherwise	Complete ATS replacement when contacts are worn is more cost effective, faster, and lower risk to safety/ATS failure.	- Maintenance cost savings. - Eliminate maintenance precision issues.

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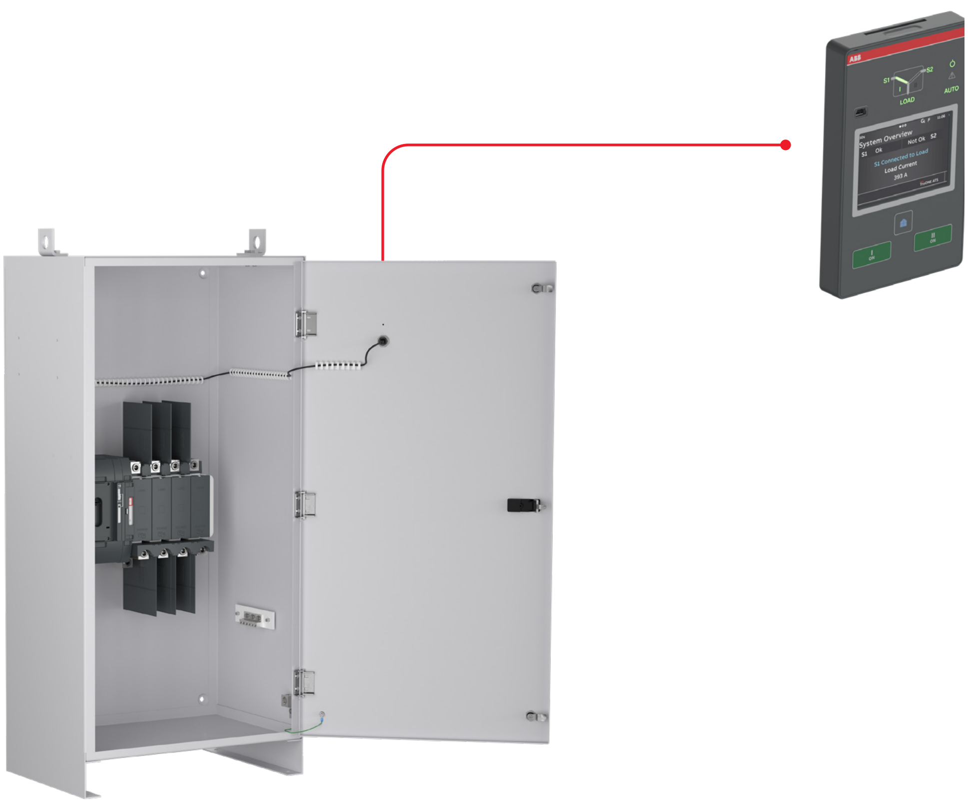
06 Typical recommended annual transfer switch maintenance plan vs. ABB low-maintenance model with predictive maintenance.

Program operations	ZTS T-series with advanced condition monitoring	New maintenance operation
De-energize the switchgear (ATS's equipped with an isolation bypass feature do not need to be de-energized).	-	No change.
Remove the arc chutes and pole covers. Consult the manufacturer's information for proper procedure. This step will allow visual inspection of the main and arcing contacts.	-	Not required.
Test and recalibrate all AC sensing and time-delay functions in the switchgear. Depending on the manufacturer, the steps required will vary.	-	No change.
Vacuum the accumulated dust from the switchgear and accessory panels. Never use air to blow out dirt. Subjecting the transfer switch mechanism to compressed air may have a detrimental effect by forcing dirt and debris into the switch mechanism.	-	No change in ZTS T-series 1600A and above. A clean all-in-one design in 1200A and under with enclosed contacts protects the ATS from dust and debris build-up on internal components - this simplifies vacuuming process.
Inspect for moisture or signs of previous wetness or dripping.	-	No change.
Clean grime with an approved non-conductive solvent. Consult the OEM for a recommendation.	-	No change.
Inspect all insulating parts for cracks or discoloration due to excessive heat. Part of any complete maintenance program is an infrared scan. This work is done prior to maintenance with normal loads applied to the gear being scanned. The resultant report will define problem areas. The use of this information will allow the maintenance provider to take a proactive approach.	Temperature monitoring.	Visual inspection for cracks or discoloration may be reduced in frequency because built-in temperature monitoring and alerts are implemented to protect the ATS insulating parts.
Inspect all main arcing contacts for excessive erosion and/or pitting. Arcing contacts are intended to be sacrificial by nature. They take the brunt of the energy when making or breaking the load. Careful attention should be paid to these contacts.	Modeled contact wear monitoring.	Contact wear level is computed by a complex and testing-backed algorithm that notifies the user when the ATS contacts are nearing and at the end of life. The servicer or facility manager need only monitor this level and prepare for replacement accordingly.
Inspect all main current-carrying contacts for pitting and discoloration due to excessive heat.	Modeled contact wear monitoring.	Contact wear level is computed by a complex and testing-backed algorithm that notifies the user when the ATS contacts are nearing and at the end of life. The servicer or facility manager need only monitor this level and prepare for replacement accordingly.
Inspect all control relay contacts for excessive erosion and discoloration due to excessive heat.	-	Switching controls are built-in & in case of unexpected failure can be replaced along with the mechanism in minutes.
Manually operate the main transfer movement to check proper contact alignment, deflection, and wiping action.	-	No change in ZTS T-series 1600A and above. A clean all-in-one design in 1200A and under with enclosed contacts protects the ATS from dust and debris build-up on internal components - this simplifies vacuuming process.
Check all cable and control wire connections to the transfer switch controller, sensing panels and other system components. Tighten if necessary.	Temperature monitoring.	All cable and control wiring should be inspected at normal intervals, however in-built temperature monitoring & alerts can allow the possibility to provide notifications for loose cables or overloading in-between inspections.
Re-energize the switchgear and conduct a test by simulating a normal source failure.	-	No change.

ABB Zenith ATS optimizes asset health and functionality

Key to the predictive maintenance features of the Zenith ZTS T-series is its detachable touchscreen human-machine interface (HMI) and its pre-programmed system of alerts for condition monitoring of contact wear and temperature. Completely electrically isolated, this HMI eliminates the need to connect potentially dangerous line voltages to the cabinet door, reducing safety risk during maintenance. It is plugged in via a Cat 5e cable, meaning the HMI is easy to replace, and in case of emergency, the ATS is fully capable of operating – as it was previously programmed – without an HMI. [Figure 07.]

With the Zenith ZTS T-series HMI, facility operators can quickly view the status of electrical contact wear without visually inspecting the contacts themselves. [Figure 08.] The "contact wear" is derived from an empirically tested algorithm that utilizes sensor data and is represented on the LCD as the ratio of wear to the projected end of the contact's functional lifecycle. Further, by factoring in this data over a rolling six-month period over the lifetime of the unit, the ZTS T-series monitors and updates the optimum timing for recommended device replacement based on actual contact wear. Built-in LCD alerts display a warning message to notify operators when the contact wear reaches 90 percent of its projected end-of-life as well as a message alarm when it reaches 100% and device replacement is strongly recommended. [Figure 9.]



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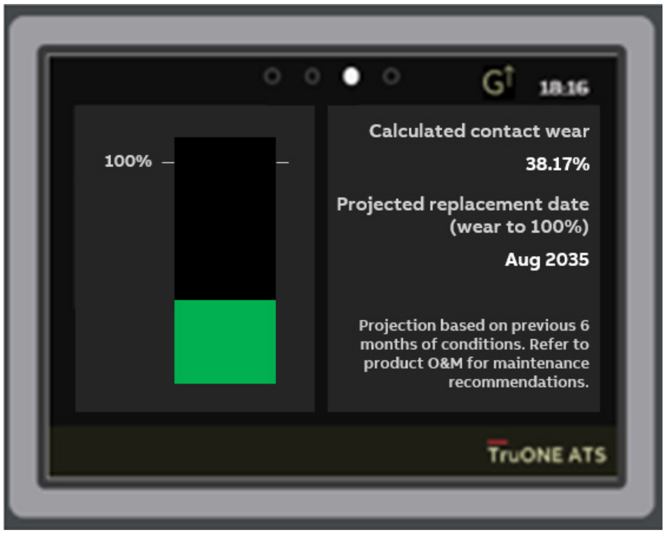
07 The HMI is plugged in the cabinet door via a Cat 5e cable.



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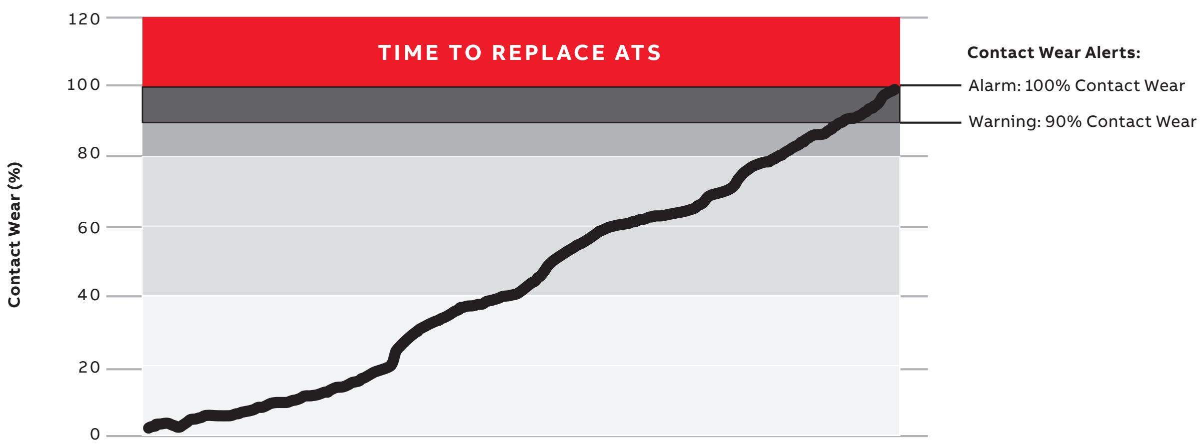
08 Zenith ZTS T-series LCD screenshot: Contact wear and end of life prediction.



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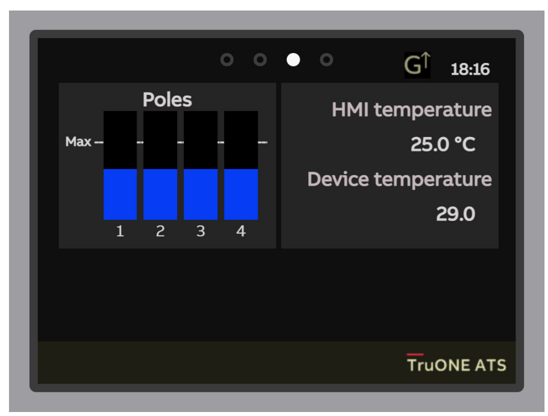
09 Representation of ZTS T-series contact wear vs alert timeline.

Providing additional insight into the ATS's health and readiness, the Zenith ZTS T-series HMI temperature screen enables operators to easily view the relative temp of each electrical contact pole versus pre-defined temp thresholds through a simple, thermometer-like graphical interface [Figure 10]. Both the height and color of each pole changes in real-time, giving users a quick situational visual into potential heat-related issues that might impact device functionality. System sensors also continually monitor the temperature of the HMI controller and the device itself, both of which are also displayed in absolute values on the same LCD screen for easy reference. The HMI temperature is a great indicator of the ambient temperature of the room in which the ATS resides, while the internal device temperature of the controller indicates the temperature within the enclosure.

Temperature alerts utilize an empirically tested algorithm that checks each average hourly pole temp against pre-defined thresholds. These alerts display as a warning or alarm on the LCD temp screen. To avoid nuisance alerts, the pole temperature warning/alert algorithm factors in both the average hourly ambient device temperature (Tamb) and the highest pole temperature (Tmax) plus the number of these consecutive hourly measurements not operating within normal parameters.

The HMI displays a service "warning" status if these hourly measurements remain over warning thresholds for three consecutive measurements/hours. After six hours, if the hourly measurements continue to exceed parameters, the LCD displays an "alarm", indicating that operations should service the ATS immediately. Using optional communication protocols, the device can be programmed to proactively email the numerical data and alerts to operators through external monitoring systems, simplifying information access that could potentially provoke faster operator remedial action. By continually monitoring temperature, the system helps users take proactive action to prevent device failures that could lead to an outage because of voltage spikes, loose cables, or faulty connections.

In addition to switch status, event and diagnostic information, the Zenith ZTS T-series transfer switch HMI is password protected and allows access to programmable set-points, time delays, and digital I/O. ABB's proprietary Ekip Connect computer software offers facilities an alternative method to controlling the ATS that provides remote as well as local access to condition monitoring data through either a USB or network connection. This same software is used across much of the ABB LV range, including Emax 2 and Tmax XT circuit breakers.



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10 Zenith ZTS T-series pole temperature monitoring.

Pole color	Temperature status	Urgency	Remediation
Red	Alarm range	High - prolonged condition may affect safe product function and longevity.	Check for overload, loose connections, and contact wear level.
Yellow	Warning range	Medium - address before condition worsens.	Check for overload, loose connections, and contact wear level.
Blue	Acceptable range	None	

Other options for accessing this data include using communication protocols to third-party SCADA/ monitoring systems that the facility may already be using (Modbus, Ethernet, etc.) or a cloud monitoring platform, such as the ABB Ability™ Energy Management and/or Asset Management Systems. Linking the Zenith ZTS T-series and ABB Ability™ makes the ATS compatible with other ABB devices. Using a laptop with Ekip Connect Software, the Zenith ZTS T-series can be configured onsite before installation, without the need for an external power supply.

In addition to the condition monitoring data, the unique modular design of the Zenith ZTS T-series 1200A and below enable facilities to further simplify maintenance protocols, reducing downtime, and lower service costs. All critical modules within this unit are customer replaceable. For example, installing a new panel inside the enclosure with this new modular design is a 72- to 161-percent savings over replacing worn electrical contacts. Plus, all the required functionalities via the mains connections (200 to 480 V AC, ±20 percent) are self-powered without the need for any external voltage transformers.

Conclusion

When the power goes out in hospitals, data centers, and other critical infrastructure facilities, ramifications go way beyond the inhabitants sitting in the dark. Lives are at risk, crucial data can be lost, and the financial cost can quickly jump into the hundreds of thousands of dollars, even millions. The expectation for power continuity is higher than ever before.

Meeting increased expectations demands new operational protocols – and new protocols necessitate new ATS design specifications. The ABB Zenith ZTS T-series, with its award-winning TruONE™ ATS built-in advanced condition monitoring capabilities, sets this new design standard. With it, facility operations get a self-contained ATS unit that provides real-time, actionable, data-based intelligence on the overall health and operating condition of the device to help facility managers reduce power downtime, minimize maintenance precision issues and lower operations costs.

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