

Case Study: 4000kVA 480V Indoor Substation Design; at Aviation Metal Manufacturing Plant-2021



High-Performance Power Upgrade: Doubling Capacity, While Halving Cost

Designed and managed by Dennis Zimmer, P.E., senior facility electrical engineer, in close collaboration with Christenson Electric. Unlike most facilities that outsource

electrical design, this project was conceived, engineered, and specified entirely in-house. Tasks included the development of capital funds, design, technical specifications, project milestones, material schedule of values, and a detailed testing schedule, resulting in improved quality, delivery speed, and significant cost savings.

This project transformed a 55-year-old, obsolete, and overloaded dual 1000 kVA substation into a modern 4000 kVA 480 V indoor substation and distribution system: all within the same footprint.

Design Philosophy

The Team followed five guiding design principles: **Simple, Innovative, Intuitive, Beautiful, and Honest.**

This philosophy kept the design focused, practical, and repeatable, demonstrating that complex challenges can be solved through engineering dedication and close collaboration.

The Challenge

The original substations were already at maximum load, obsolete, overheating, and unsafe, yet no additional floor space was available. A traditional kind-for-kind replacement was estimated at twice the final project cost, but that option didn't add any more capacity. The team's goals: **maintain existing footprint, double the power, improve the distribution & safety, deliver a speedy schedule and reduce cost and downtime.**

The Solution

Working with together Christenson Electric, Omega Morgan, Vertiv, ABB, Schneider Electric, and CED, the "A Team" delivered an innovative design-build solution:

- Custom 4000 kVA transformer impedance & distribution design with rotated core orientation to reduce line-up width.
- Enclosed HVL MV section current limiting fuses & lighting protection plus custom bussing.
- Advanced electronic overcurrent protection and monitoring: Kirk Key isolation, SEL relays for protection, monitoring, & control, SPD/TVSS, and electronic-trip breakers with ERMS.

- Fully networked sub-metering, zonal distribution sections (QED large breakers & I-Lines smaller breakers) and continuous-duty transformer fan cooling.
- Custom “narrow” gasketed-doors QED enclosures’ (an innovative first) no more breakers without doors.
- Laser field measurements, custom conduit bends and 3D modeling ensured a perfect installation fit. The extremely tight installation schedule necessitated advanced laser field measuring & 3-D modeling and coordinated machine shop work.
- Overhead J-Cans with pre-wired Polaris lugs reaching manufacturing areas, overhead emergency LED lights, floor poly chevron striping and a movable safety barrier all around.
- Comprehensive arc-flash & power studies, breaker settings, and commissioning coordinated directly with manufacturers, doubling the warranty period.

Engineering design and specification reached 90% completion in under two weeks, followed by contractor bids & permitting, factory equipment buildouts and carefully monitored supply-chain milestones with subsequent demolition, delivery, installation and commissioning occurring in just six days, over the Christmas shutdown period.

Sustainability and Quality

All removed equipment & wiring was responsibly recycled or refurbished. The installation achieved zero field rework, with every shop pre-manufactured conduit fitting precisely.

The design exceeded NFPA, EHS, and IEEE standards, integrating multiple layers of fail-safe reliability and maintainability.

Results

Power Capacity: Increased from 2000 kVA to 4000 kVA.

Cost Savings: Delivered at 50% of original estimate at twice the power, delivering 4X project’s overall value, saving \$millions.

Schedule: Completed from design concept to installation commissioning in record time. Engineer performed double-duties as Project manager and Construction manager.

Repeatable Success: The design was later replicated for two additional 4000kVA substations with similar success.

Recognition

Originally featured in Boeing's The Cutting Edge Newsletter (May 2022) (Article adapted for web from the original technical feature). Article can also be viewed at my LinkedIn page: https://www.linkedin.com/posts/dzimmerpe_innovation-aviation-manufacturing-activity-7193290081825099776-brgn?utm_source=share&utm_medium=member_desktop&rcm=ACoAAAfYIBQqRsUp7PQxW0XKOI0fG_sgU6GY8

Summary

The 4000 kVA Substation Upgrade project exemplifies how disciplined engineering, proactive collaboration, and thoughtful innovation can deliver double capacity at half the cost, without expanding the footprint or extending downtime. Unfortunately, Dennis left Boeing when engineering excellence & successes like this weren't fully appreciated. Don't know how they missed that with evidence like this!

Back of Substation:



About the Author:

Dennis Zimmer is a professional electrical engineer with more than 35 years of experience in Manufacturing, Aerospace, MEP, AE, Facility Engineering and Controls across commercial, manufacturing, mixed-use, institutional, and industrial projects. Dennis has served as a principal engineer, middle manager, and business owner. Over the course of his career, Dennis has held P.E. licenses in 15 states.

He has also been accredited by WA L&I to perform electrical field evaluations for over 7 years and has additional Machine Safety & Risk Assessment certification. Dennis also has access to FM Global's Approval Guide.

Dennis has had long and varied technical career; in addition to engineering, spanning Avionics Repair, Wet Chem Lab, Asbestos Abatement & Well Operator.

His passion is mentoring engineers in technical mastery, business acumen, and leadership excellence.

Thank you, Dennis

