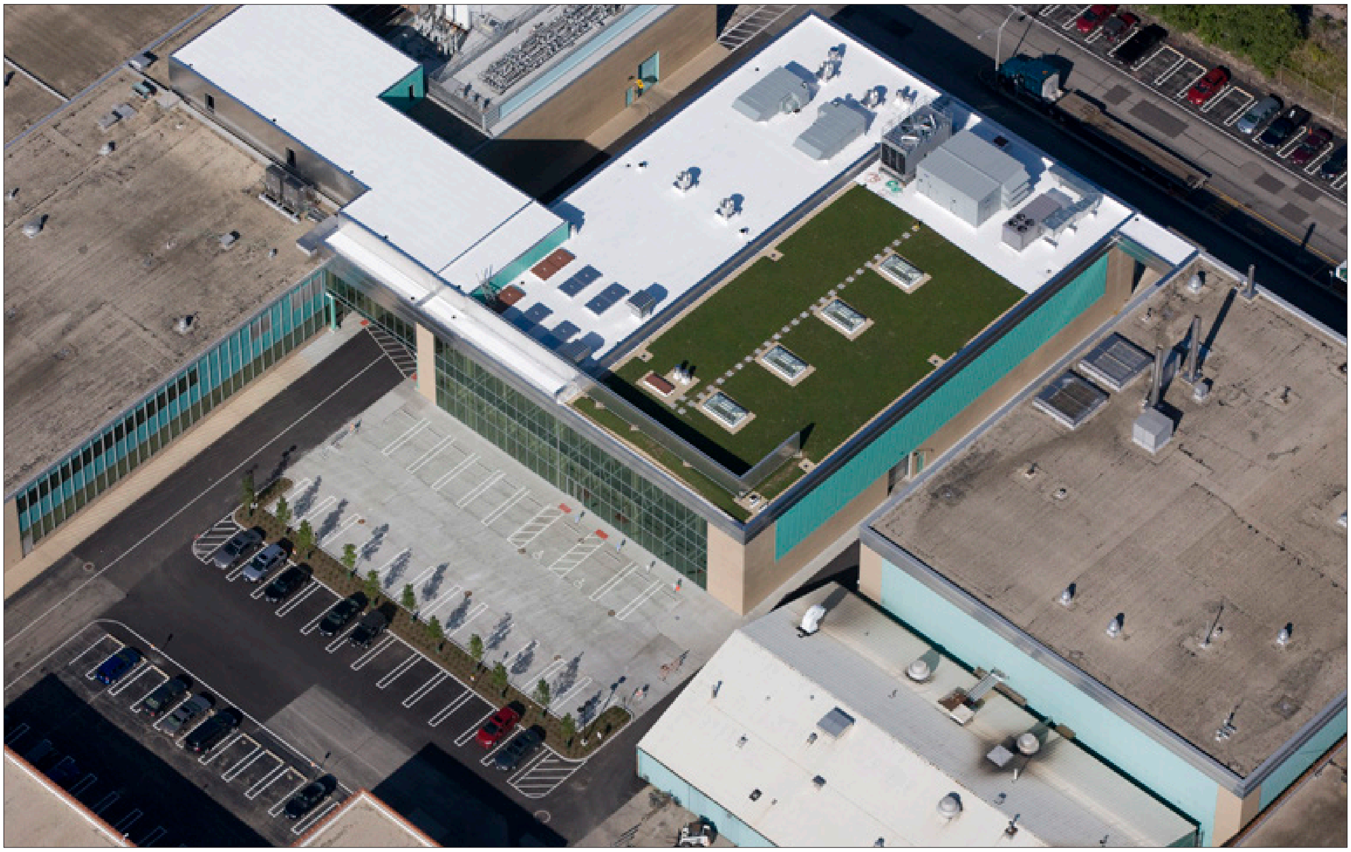
S&C Electric Company's



Advanced Technology Center

S&C Electric Company's Advanced Technology Center

Generator Room.

S&C Electric Company—one of Chicago's leading manufacturers—continues to invest in the future with a striking new addition to the area's high-tech scene . . . the company's unique Advanced Technology Center ("ATC").

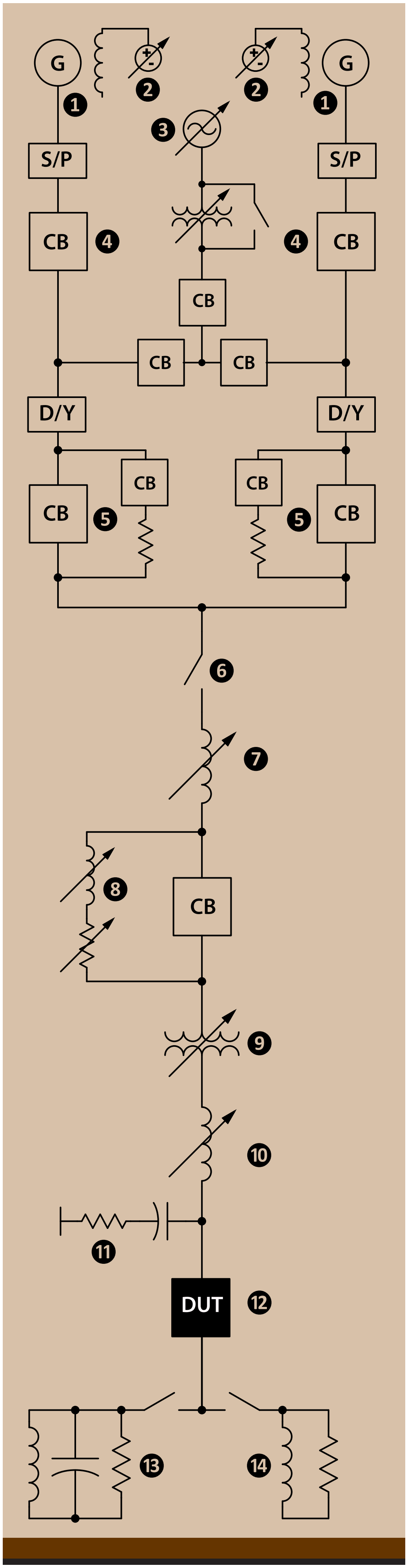
This state-of-the-art facility will enable S&C to accelerate development and delivery of innovative electrical switching and protection products in the United States, including the highly-sophisticated automatic service restoration, energy storage, and power quality equipment needed for the Smart Grid.

At the heart of the ATC is the Nicholas J. Conrad Laboratory; it has two 850-megawatt electrical short-circuit test generators that can test up to 100 kA and up to 230,000 volts. The laboratory will allow S&C to perform quality control and other testing at the Chicago industrial campus, instead of relying on costly, time-consuming visits to test labs in Europe.

The Nicholas J. Conrad Laboratory has been accredited to ISO 17025:2005 by the American Association for Laboratory accreditation for the following tests: Line Charging, Cable Charging, Interrupting, Fault Making, Short-Time and Peak Withstand, Making/Breaking, Breaking, and Critical Current.

In addition to the world-class high-power testing laboratory, the ATC houses S&C's Product Innovation offices, plus expanded molding operations. S&C is the largest manufacturer of high-voltage cycloaliphatic epoxy insulators in the U.S. These insulators are superior to porcelain insulators for many reasons—including their ability to integrate intelligent voltage and current sensing, as well as control, diagnostic, and automation components. Such components are essential to equipment for the Smart Grid.

The ATC is one of the most environmentally-friendly facilities of its kind in the world. The 43,000-square-foot structure minimizes environmental impact through numerous energy-efficient and sustainable design features, including an 8,000-square-foot green roof, use of recycled content and locally-produced building materials, and other innovative measures. The ATC holds LEED "Gold Certification" rating per the U.S. Green Building Council. It's one of the first industrial buildings in the Chicago metropolitan area to hold such a rating.



Nicholas J. Conrad Laboratory Single-Line Diagram

❶ **Short-circuit-rated generators** are two-pole, synchronous machines rated 850 MVA, based on open-circuit voltage and short-circuit current. The two 4-kV windings per phase can be connected in series or parallel, in delta or wye, and produce 4 to 13.75 kV. The laboratory has a maximum short-circuit test capability of 100 kA symmetrical, 270 kA peak.

❷ **Super-exciters** provide normal field excitation using a power-electronic-rectified dc source, supplying 500 A to the field windings. During short-circuit testing, the field current jumps to 5,000 A. The exciters can deliver up to 5 MW as "super-exciters," to maintain high field current and produce steady short-circuit current.

❸ **4.5-MVA variable-frequency drive** starts each generator individually, then synchronizes them in parallel. The machines "idle" at 35 to 40 Hz and are accelerated to 50 or 60 Hz just before the test operation, when the drive is disconnected. The low machine speed reduces power consumption and heating losses inside the generators, which have very limited cooling capacity.

Power for the testing is supplied by the stored energy of the rotors. Each generator stores 150 megajoules (150 MW-seconds) in its 20-ton (18,000-kg) rotor. This energy is used to supply the losses during short-circuit, load-circuit, or arcing-fault tests. Short-circuit tests from 3 to 10 cycles result in a small droop in machine speed—from 60 to 58 Hz, while one-second arcing-fault tests result in a speed droop from 60 Hz to 48 Hz.

❹ **80-kA air-blast main breakers** provide redundant backup to the auxiliary breakers.

❺ **63-kA auxiliary breakers** "back up" the device under test and protect against inadvertent short-circuits. Each breaker has two series-connected vacuum interrupters per phase, with resistor snubbers to control switching transients. These breakers operate with every test operation; contact wear is minimized by means of synchronous interrupting control.

❻ **Controlled-closing make switch** rated 100 kA symmetrical, 270 kA peak closes "point-on-wave" within 0.5 millisecond, to control asymmetrical current peak on a per-pole basis.

❼ **Current control inductors** reduce the short-circuit test current from the maximum of 100 kA to less than 1 kA.

❽ **Peak current control inductors and resistors** reduce the first asymmetrical current peak if the X/R of the generators exceeds their rating. The inductors and resistors are bypassed after a few cycles to reduce heating.

❾ **220-MVA short-circuit-rated transformers** (six single-phase units) can be connected three-phase or single-phase, to step up generator voltage to the required test voltage. The four secondary windings, nominally rated 15 kV, 5 kA short-circuit current, can be connected in parallel or series. Output voltage range is 5 to 104 kV three-phase, and up to 240 kV single-phase.

❿ **High-frequency inductors** provide high transient recovery voltage frequencies for the 10%, 30%, and 60% test duties of circuit breakers and reclosers.

⓫ **Transient recovery voltage control** comprised of capacitors, resistors, and inductors "tune" the natural frequency of the test circuit to match transient recovery voltage specifications.

⓬ **Device under test**

⓭ **Load resistors, inductors, and capacitors** for load switching and capacitor-, line-, and cable-switching tests.

⓮ **Distribution line simulator** uses very-high-frequency inductors, resistors, and capacitors to create transient recovery voltages representative of overhead line faults.

Nicholas J. Conrad Laboratory 50/60-Hz Testing Capabilities①

Circuit Breaker and Recloser Three-Phase Tests

Rated/Test Voltage, kV	Maximum Current, kA
15	31.5
17	25
27	25
38	15

Circuit Breaker Single-Phase Tests

Rated Voltage, kV	Test Voltage, kV	Maximum Current, kA
15.5	13.4	63
29	23.5	31.5
38	32.9	25

Disconnect Switch Three-Phase Tests

Ten-Cycle Duration Three-Phase Momentary/Peak Withstand Maximum Current, kA		
Constant Fault Current	Peak Current Mitigated By Switched Inductors	Current Droops to 80%
40	80	100

Short-Time Withstand Maximum Current, kA	
Two-Second Duration	Three-Second Duration
100	80

Loadbreak Switch Three-Phase Tests

Load Switching	
Rated/Test Voltage, kV	Maximum Current, A
15.5	2000
29	1200
38	1200

Fault Closing		
Rated Voltage, kV	Test Voltage②, kV	Maximum Current③, kA
15	9	63/80/100
15.5/27	15.5	40/50/63
27	27	25/31/40
38	22	25/31.5/40
38	38	12.5/16/20

Fuse Single-Phase Tests

Rated/Test Voltage, kV	Maximum Current, kA
15.5	50
29	31.5
38	20

Arcing Fault Three-Phase, 0.5-Second Tests

Rated Voltage, kV	Test Voltage②, kV	Maximum Current③, kA
15	15	40
15	7.9	63
27	27	25
27	15.5	40
38	38	12.5
38	27	25

① All current ratings are symmetrical. In each instance, the first peak asymmetrical current is 2.7 times the symmetrical current unless the current is controlled by additional circuit resistors or switched peak-current-limiting inductors.

② Single-phase testing at phase-to-ground voltage is permissible for single-phase switches.

③ Multiple current capability varies with standard requirements X/Y/Z, where:

X = Constant fault current;
Y = Peak current mitigated by switched inductors;
Z = Current droops to 80% at 10 cycles.

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