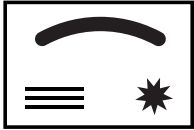




EDITION 2

VOLUME 1

# THE TOP 10 FEATURES OF SOUTHWIRE'S PATENTED LIQUID-COOLED CHARGING CABLE



## PATENTED CABLE DESIGNS

Southwire's design, covered by US patent 10,811,170 and European patent 3,459,087, creates a forced cooling & liquid circulating

assembly that enables the system to achieve the highest heat transfer coefficient, high power charging current, and ultra-fast charging time.



## HIGH CURRENT & FAST CHARGING

Air-cooled charging cables typically yield less than 200 amps of charging current. Southwire's patented technology can supply currents from 400 amps to 1,000+ amps, which is 2-5 times greater than conventional air-cooled EV cables.



## HEAT GENERATION

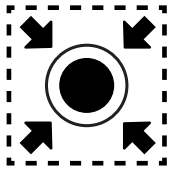
EV cables can be exposed to a wide range of operating temperatures depending on the specific type of insulation material. Heat

generated by copper wiring derates the current carrying capacity of the cables; thus, heat dissipation efficiency is a critical part of the design.



## COOLING DEVICE & CONFIGURATIONS

Southwire's closed-loop cooling design strategically connects the load station with energy storing battery packs with the power supply source and the coolant pump station. This innovative configuration using the supply vs. return coolant hoses with a long coolant pathway with bifurcation points allows the heat to be exchanged optimally using the largest surface area.



## COMPACT & FLEXIBLE DESIGN

As the electric charging current increases, the standard listed cable may become too large, too heavy, and too inflexible for a consumer to use. Southwire's patented design produces the most

compact size to carry the highest current rating without sacrificing the mechanical durability and electrical performance.



## SOURCING OF QUALITY MATERIALS

From high performance compounds, flexible braided shields, high temperature tubing for coolant, to marker & binder tapes, Southwire sources the most reliable and consistent raw materials and cable components via a sustainable supply chain and global vendors.



## COMPONENTS & CABLE DESIGN

Many factors impact charging efficiency, including the conductor size, coolant type,

tubing wall thickness, number of supply vs. return coolant hoses, the layout & the length of the circulation paths, the intimate physical contact area where heat can be exchanged, etc. All these parameters are reviewed and designed into our complete cable design.



## UNPARALLELED ENGINEERING SUPPORT

Southwire's CableTechSupport™ Services team provides Re<sup>3</sup>™ engineering consultation services through the custom design of reinforced cables and the support of critical infrastructure projects where resilience and reliability are non-negotiable.



## ONE-STOP SHOP TO SAVE TIME & COST

Southwire offers a complete line of wire & cable solutions to complement EV infrastructure

installations, including copper and aluminum SIMpull® building wire, SIMpull® Cable-in-Conduit (CIC), bare copper grounding conductors, pre-terminated power assemblies, Maxis® pulling equipment, cable management solutions, battery cables, primary lead wire, hook-up wire, communication cables, control cables, underground medium voltage cables, and halogen-free HDPE conduits.



## SUSTAINABILITY

Many of Southwire's wire & cable products are compliant with RoHs and REACH, including EV solutions. We utilize energy-saving manufacturing equipment, processes, and facilities to deliver power responsibly.



For more information, please contact cabletechsupport@southwire.com or visit [southwire.com](http://southwire.com).

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EDITION 9

VOLUME 1

# 6 STEPS OF THE FORMAL ENGINEERING PROCESS WITH 6 TOOLS TO DESIGN EV CHARGING & INFRASTRUCTURE CABLES

Written by Dr. Yuhsin Hawig, VP of Applications Engineering and Edwin Marquez, Engineering Manager

## ENGINEERING PROCESS



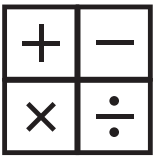
### PROJECT TIMELINE & OVERVIEW

Comprehensive overview of overall project scopes, timeline, and deliverables with stakeholders and clients.



### TECHNICAL SPECIFICATIONS

Review technical specifications, codes, industry standards, end user requirements, system limitations, and property vs. performance evaluations, such as dry vs. damp vs. wet locations vs. hazardous locations.



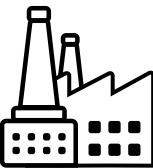
### ELECTRICAL CALCULATIONS

Conduct electrical calculations to meet power (kW), system voltage (volts), and current (amps) requirements to create the most cost-effective EV solution.



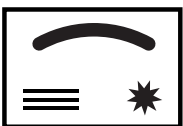
### CABLE SIZING & DESIGNS

Size copper or aluminum conductors; select dielectric insulation types, optional cable components, shielding designs, overall jacketing materials, preferred colors, required markings or print legends.



### MANUFACTURING COMPLIANCE

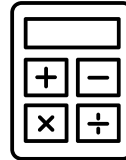
Determine manufacturing tolerances for conductor diameter, insulation & jacket thickness, and maximum cable diameter based on designs, standards, specifications, final assemblies, connectors, accessories, and raceways.



### TESTING, VALIDATIONS, & APPROVALS

Validate proposals via in-house testing or through a nationally recognized testing laboratory (NRTL), manufacturing plant audits, qualification & certification document submittals, and secure formal customer approvals.

## 6 ENGINEERING TOOLS



### POWER CONVERSIONS

Conduct electrical conversions to meet power (kW) requirements, current carrying capacity (amps), and system voltage ratings.



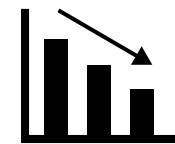
### MAXIMUM AMPACITY MODELING

Utilize multiple software to model different operating conditions, environmental parameters, installation methods, and cable routings to achieve maximum ampacity without overheating or thermal runaway events.



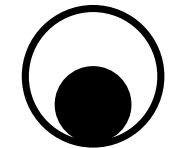
### ELECTRICAL & SHORT CIRCUIT CALCULATIONS

Conduct short circuit calculations or provide conductor burndown curves. Supply advanced electrical data including impedances, DC/AC resistance, charging current, capacitance, reactance, insulation resistance, and dielectric losses for system modeling.



### VOLTAGE DROP VALIDATIONS

Verify conductor sizing vs. installation lengths vs. percentage of voltage drop to ensure the long-term functionality and performance of the electrical equipment.



### CONDUIT FILL RATIO & NEC COMPLIANCE

Confirm conduit fill ratios, jamming probability, below grade to above ground transitions, couplers/connector recommendations, and NEC code compliances.



### ROUTING & CABLE PULLING SUPPORT

Deliver full cable pulling calculations, alternative routing support, determine maximum pulling tensions, sidewall bearing pressure, and minimum bending radius for all cable products.



EDITION 14

VOLUME 1

# 20 THINGS YOU MUST KNOW

ABOUT SIMpull XHHW-2® CONDUCTORS

WRITTEN BY

Dr. Yuhsin Hawig, VP of Applications Engineering  
Edwin Marquez, Director of Applications Engineering  
Radek Kochanowski, Applications Engineer



## PERMANENT FRICTION REDUCTION WITH NOLUBE®

Southwire first invented SIMpull® formulations to reduce the cable Coefficient of Friction (CoF) by listening to contractor feedback over 16 years ago. As a result, more than 10 patents were granted since 2008 to protect the innovation. A proprietary low-friction agent is dispersed in the compound prior to cable extrusion with the advantage that the imbedded lube creates a permanently slick surface covering 360° of the cable circumference. SIMpull XHHW-2® conductors feature a reduced CoF value of 0.16 compared to 0.35 for non-SIMPull® conductors without any field-applied pulling lubricant which can be messy, inconsistent, and will wear off over time.



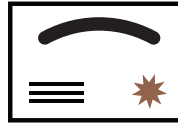
## WIDE RANGE OF SIZES

Southwire offers SIMpull XHHW-2® Copper Conductors in sizes 8 AWG & larger and SIMpull XHHW-2® Aluminum Conductors in sizes 6 AWG & larger as standard stock items regardless of shipping lengths or packaging types. XHHW-2 conductors in circuit sizes including 14, 12, and 10 AWG are non-SIMPull® products and are silicone-free. SIMpull XHHW-2® conductors contain a small amount of silicone encapsulated via an XLPE-based insulation. Due to the extruded properties of the finished conductor, it is highly unlikely that the use of these SIMpull® products, under applications permitted per NFPA 70® National Electrical Code® (NEC®), would result in airborne silicone.



## NUMEROUS FIELD ADVANTAGES

Slick SIMpull XHHW-2® insulation minimizes the chances for the cable to be torn apart or for the insulation to be nicked severely and expose the conductors during challenging long pulls. A reduced pulling tension to pull larger feeder cables through longer distances can be achieved using SIMpull® cables. Shorter pulling time and less labor are the top advantages of using SIMpull® cable designs as they can deliver substantial cost savings for the overall project. Additionally, unexpected expenses and delays due to repairs or replacement of the damaged cables can be eliminated. SIMpull XHHW-2® insulation provides better long-term performance compared to THHN due to XLPE's better electrical, thermal, physical, and chemical properties compared to PVC.



## PRODUCT PERFORMANCE GUARANTEE

Southwire Company, LLC guarantees that all SIMpull® products including SIMpull XHHW-2® conductors made with either copper or aluminum conductors in all sizes can be installed for any NEC® allowed applications without requiring the field application of lubricant to facilitate pulling through a PVC duct or a metal conduit, provided that the instructions published on the Southwire website are followed.



## SUPERIOR DIELECTRIC PROPERTIES

XHHW-2 is extruded with a single layer of crosslinked polyethylene or XLPE insulation, which is different from the dual-layer THHN coextruded with a PVC insulation under a nylon jacket. XLPE used in Type XHHW-2 exhibits a lower dielectric constant, a greater AC breakdown strength, and a significantly higher insulation resistance compared to the PVC insulation in THHN. For example, the minimum insulation resistance in water at 15°C for 8 AWG XHHW-2 per UL 44 is 2130 MΩ·1000 ft, which is more than 3.5 times higher than the requirement for Type THHN/THWN-2 of 595 MΩ·1000 ft per UL 83.



## THICKER INSULATION WITHOUT JACKET

Type XHHW-2 is designed per UL 44 (thermoset-insulated cables), with a thicker insulation across all sizes compared to THHN/THWN-2 without the need for an extra nylon jacket. For example, the minimum average insulation thickness required for 8 AWG XHHW-2 is 45 mil, which is 50% thicker than the minimum average insulation thickness for the same size THHN/THWN-2 at 30 mil. The thicker insulation for XHHW-2 reduces the dielectric stress exerted on the insulation wall, which can extend the longevity of XHHW-2 cables compared to THHN if both are operated under identical conditions.



# 20 THINGS YOU MUST KNOW

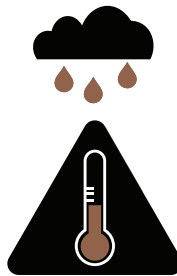
ABOUT SIMpullXHHW-2®



## VOLTS

### HIGHER VOLTAGE RATING

XHHW-2 conductors can be dual-rated for 600V/1000V in the U.S., as opposed to THHN/THWN-2, which is only rated for 600V. The 1kV rating is critical if the electrical system encounters any overvoltage events exceeding 10% of its 600V system voltage, or 660V. As a result, XHHW-2 is frequently specified for industrial applications where circuits are more likely to exceed 600V. XHHW-2 single conductors in sizes 14, 12, and 10 AWG are also dual-rated for SIS (Single Insulated Switchboard) and are routinely used for panels or utility substation switchboards.



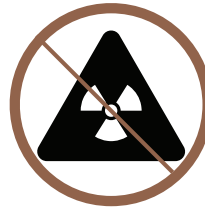
### HEAT & MOISTURE STABILITY

Type XHHW designates Crosslinked Polyethylene (X for XLPE), High Heat (HH) and Wet or Water (W) Resistance. XHHW conductors are rated for 75°C (167°F) wet and 90°C (194°F) dry. XHHW-2 denotes the improvement in insulation over XHHW that allows the conductors to be operated up to 90°C (194°F) continuously in both wet and dry locations. SIMpull XHHW-2® conductors can sustain a greater emergency overload temperature of 130°C compared to 105°C for THHN. SIMpull XHHW-2® conductors also exhibit a higher maximum short-circuit temperature rating of 250°C compared to 150°C for THHN. XHHW/XHHW-2 is a necessity for heavy-duty industrial systems that might experience short circuit and overload occurrences.



### LOW TEMPERATURE FLEXIBILITY

XHHW-2 is made of a thicker insulation, but it is more flexible than THHN at low temperatures because the polyethylene-based resin in XHHW-2 has a Ductile/Brittleness Transition Temperature, or DBTT, below -70°C, which is much lower than that of PVC. XHHW-2 retains its flexibility at low temperatures, allowing for a minimum installation temperature of -40°C (-40°F) compared to -10°C (14°F) for THHN/THWN-2. Thus, XHHW-2 is often specified for outdoor installs during winter months or if better flexibility is essential. Type XHHW-2 made with XLPE is hardier compared to PVC-based THHN due to its crosslinked chemistry. XLPE provides greater tensile strength, elongation, and impact resistance compared to PVC.



### IMPROVED SAFETY

XHHW-2 is naturally **halogen free** unlike THHN, which contains PVC. The presence of a halogen in THHN (chlorine from PVC insulation) can release toxic hydrogen chloride (HCl) at elevated temperatures. Such corrosive gases can spread quickly and cause concerns for safety and the environment. SIMpull XHHW-2® conductors do not produce harmful acid gas when overheated or burned and, therefore, are a safer building wire choice compared to THHN.



### SUNLIGHT RESISTANCE

Color fading on cable products is normal, and it is common for any wires and cables that are exposed to UV. Faded color does not always correlate to dielectric breakdown or degradations. In fact, UL does not require an insulation or a jacket material to retain its original color as a requisite to be certified as sunlight resistant. **SUN. RES.** (sunlight resistant or SR) is printed on Southwire's XHHW-2 sizes 8 AWG & larger and thus, can be installed outdoors and exposed to weather conditions. This optional marking is based on UL's weather chamber evaluation that material retains at least 80 % of its initial tensile properties after 720 hours of UV exposure.



### FLAME RETARDANCY

SIMpull XHHW-2® conductors are produced using a premium grade of XLPE formulation with a synergistic flame-retardant package to suppress flame propagation effectively. XHHW-2 in sizes 350 kcmil & larger is marked with **FT4**. This optional vertical flame rating is based on a UL 2556 test method where finished cables must not exhibit charred material beyond a length of 1.5 m (5 ft) from the lower edge of the burner face. XHHW-2 in sizes 1/0 AWG & larger is also printed "**FOR CT USE**" or for Cable Tray use, which is required for many industrial and commercial applications per NEC®.



**Southwire**®

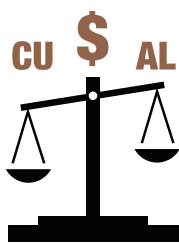
# 20 THINGS YOU MUST KNOW

ABOUT SIMpullXHHW-2®



## CHEMICAL PROTECTION

When thermoset XLPE is used for XHHW-2, it hampers the liquid diffusion process and delays chemical attack by water, grease, oil, or gasoline. The Water Vapor Transmission Rate, or WVTR, for the XLPE-based XHHW-2 is significantly lower compared to the PVC in THHN simply because XLPE is hydrophobic in nature and will absorb less liquid or vapor. Southwire's XHHW-2 in sizes 8 AWG & larger is marked "GASOLINE AND OIL RESISTANT II" per UL 44 as the tensile properties of the insulation exceeded 65% of its original values after immersion of the finished wire in oil for 60 days at 75°C.



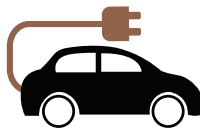
## CU TO AL CONVERSION TO SAVE COST

Many end-users are interested in the conversion of copper (Cu) to aluminum (Al) conductors for many wire & cable products including SIMpull XHHW-2® conductors. Rising copper prices and the volatility of the metal supply chains will continue to dictate the Cu vs. Al spec requirements. Both Cu and Al SIMpull® products can deliver the same performance and achieve a long life. Southwire's CableTechSupport™ Services offer comprehensive ampacity modeling under complex installation configurations or unique environmental conditions to ensure that upsizing of Al to match the maximum current carrying capacity of Cu at a specific temperature is sufficient.



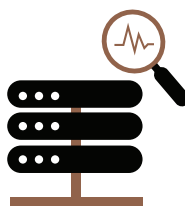
## VERSATILE DESIGNS AND COLORS

SIMpull® products can be made in single conductor, multi-conductor paralleled, or multi-conductor plexed configurations. Multi-conductor assemblies are most popular for heavy-duty industrial or large-scale commercial applications. Plexing of two or more conductors together prevents jamming when the conduit fill is high. For example, four (brown, orange, yellow, gray) SIMpull XHHW-2® conductors quadplexed together plus a green ground is commonly deployed for data center projects. A parallel design is less expensive but might cause conductors to jam in a narrow duct and incur severe tearing or damage. There are 10 solid colors with over 50 different striping variations, which can be customized to create the best visual identification for the most complex wiring layout.



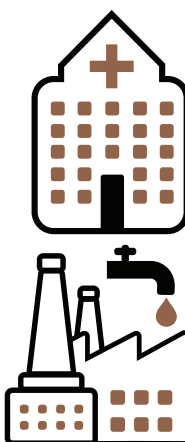
## EV INFRASTRUCTURE

All SIMpull® product lines including THHN and XHHW-2 designed with copper or aluminum conductors can be utilized to power EV charging stations. The low-friction surface allows the multi-conductor assembly to be pulled into PVC ducts or HDPE conduits effortlessly to accelerate the high-volume installation and to shorten the construction period in areas with high populations. Many EV infrastructure circuits have a system voltage that exceeds 600V. Therefore, it is common to select SIMpull XHHW-2® conductors that are dual-rated for 600V/1000V.



## DATA CENTER

SIMpull XHHW-2® conductor, dual-rated for 600V/1kV, is the best product for data centers that operate 24/7 under a heavy load factor. Overvoltage occurs when the voltage exceeds its design limit by 10%. Overvoltage events can be triggered internally by switching and faults or externally by a lightning strike and may harm equipment and electronics. A sustained overvoltage event might also accelerate the breakdown of insulation. XHHW-2 is made of a pure crosslinked polyethylene resin with a much greater dielectric breakdown strength compared to a blended PVC formulation containing a high concentration of additives such as plasticizers.



## HEALTHCARE & WASTEWATER TREATMENT FACILITIES

SIMpull XHHW-2® conductors are routinely specified by healthcare facility designers because a dielectric constant of 3.5 or less is recommended per section 517.160 of the NEC®. Type THHN with a PVC insulation exhibits a dielectric constant that is 70% greater than that of XHHW-2 based on a pure polyethylene resin. A higher dielectric constant translates to greater dielectric losses in the PVC insulation or a higher leakage current for THHN. SIMpull XHHW® products have also been specified for wastewater treatment projects because of the superior water repellency and chemical resistance of the crosslinked chemical structure compared to its thermoplastic or non-crosslinked THHN counterpart.

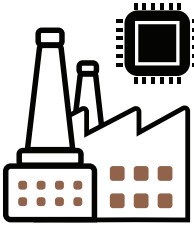


EDITION 14

VOLUME 1

# 20 THINGS YOU MUST KNOW

ABOUT SIMpullXHHW-2®



## SEMICONDUCTOR & INDUSTRIAL MANUFACTURING

The **CHIPS and Science Act**, enacted in August 2022, will boost the expansion of nanochip production in the U.S. over the next 5 years.

SIMpull XHHW-2® products, with either copper or aluminum conductors, have been installed as an equipment grounding conductor (EGC) or a multi-conductor cable assembly to power the mega-scale semiconductor manufacturing factories. Southwire's complimentary engineering services including cable pull modeling, maximum conduit fill ratio validation (less than 40% per NEC®), and voltage drop calculations are offered to support long and complex pulls, and to eliminate non-compliance issues on the jobsite.



## BIPARTISAN INFRASTRUCTURE LAW

The number of product inquiries and bid submittals to support government projects including Department of Transportation (DOT) and

Department of Energy (DOE) will continue to rise as a result of the **Bipartisan Infrastructure Law** (BIL) that was enacted in November 2021. SIMpull® products including XHHW-2 have been used to power many infrastructure projects and Southwire's CableTechSupport™ Services team can review the state-specific regulations and prepare signed compliance letters to accelerate government approvals.