3M™ Aluminum Conductor Composite Reinforced (ACCR)
High-capacity transmission conductor

English (U.S.) Units

Protecting Grid Integrity

More amps, more confidence

3M

In today's complex world, protecting grid integrity is a growing challenge. Aging infrastructure is burdened with changing power flows as renewable generation is integrated and traditional sources are retired. All of this is happening amid growing environmental and regulatory concerns. 3M offers a fast and potentially cost-saving way to increase capacity, achieve greater clearances and meet today's strict reliability standards – helping you keep the lights on for years to come.

Now **you** have

Advanced technology to protect your grid

To help solve today's toughest transmission challenges, 3M developed an advanced, high-capacity overhead transmission conductor: **3M™ ACCR** (**Aluminum Conductor Composite Reinforced**). It is engineered to maximize the capacity of existing lines, helping you provide a more robust and flexible grid. Reconductoring with 3M™ ACCR can help you alleviate the scheduling, budgetary and regulatory risks of upgrading lines in areas with dense populations, strict permitting requirements or limited land availability.

3M ACCR is designed to replace ACSR or ACSS on existing structures at the same tensions and clearances, giving you up to twice the ampacity without the risks of a major construction project. Your line can be back in service fast, within budget, and with minimal community and environmental impacts. And 3M ACCR has proven its reliability in installations around the world – so you can be confident in the integrity of your transmission lines, even in challenging environments.

To learn more about 3M™ ACCR, NERC reliability standards, and managing grid integrity in a changing world, download our white papers at 3M.com/accr

Maximize the value of your grid

Running more amps on existing structures can reduce ratepayer impacts from major upgrade projects while delivering more value to shareholders from existing assets. Upgrading with 3M ACCR can also help relieve transmission constraints, simplify compliance with regulatory standards, enhance reliability and provide a robust system to support your advanced grid investments.

Most importantly, 3M ACCR's dependable operation helps protect the integrity of your grid – for long-term value you can count on.

the power!

What is 3M ACCR?

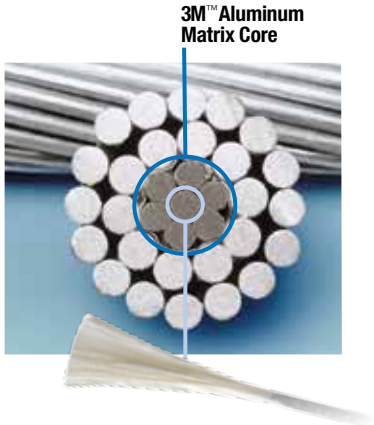
This high-capacity transmission conductor has a high-strength, lightweight aluminum matrix core. The outer, current-carrying strands are composed of a hardened aluminum-zirconium alloy. 3M ACCR's core and outer wires are both helically stranded for greater strength and conductivity.

3M ACCR is similar in construction and dimensions to ACSR. 3M ACCR, however, has a higher strength-to-weight ratio and lower thermal expansion than comparably sized steel core conductors – so it is lighter and sags less, even at higher operating temperatures. This in turn allows higher ampacities at equivalent tensions and clearances. 3M ACCR retains its performance over decades of high temperature use and is stable in a wide range of environmental conditions.

Core Property Comparison: ACCR vs. ACSR/ACSS

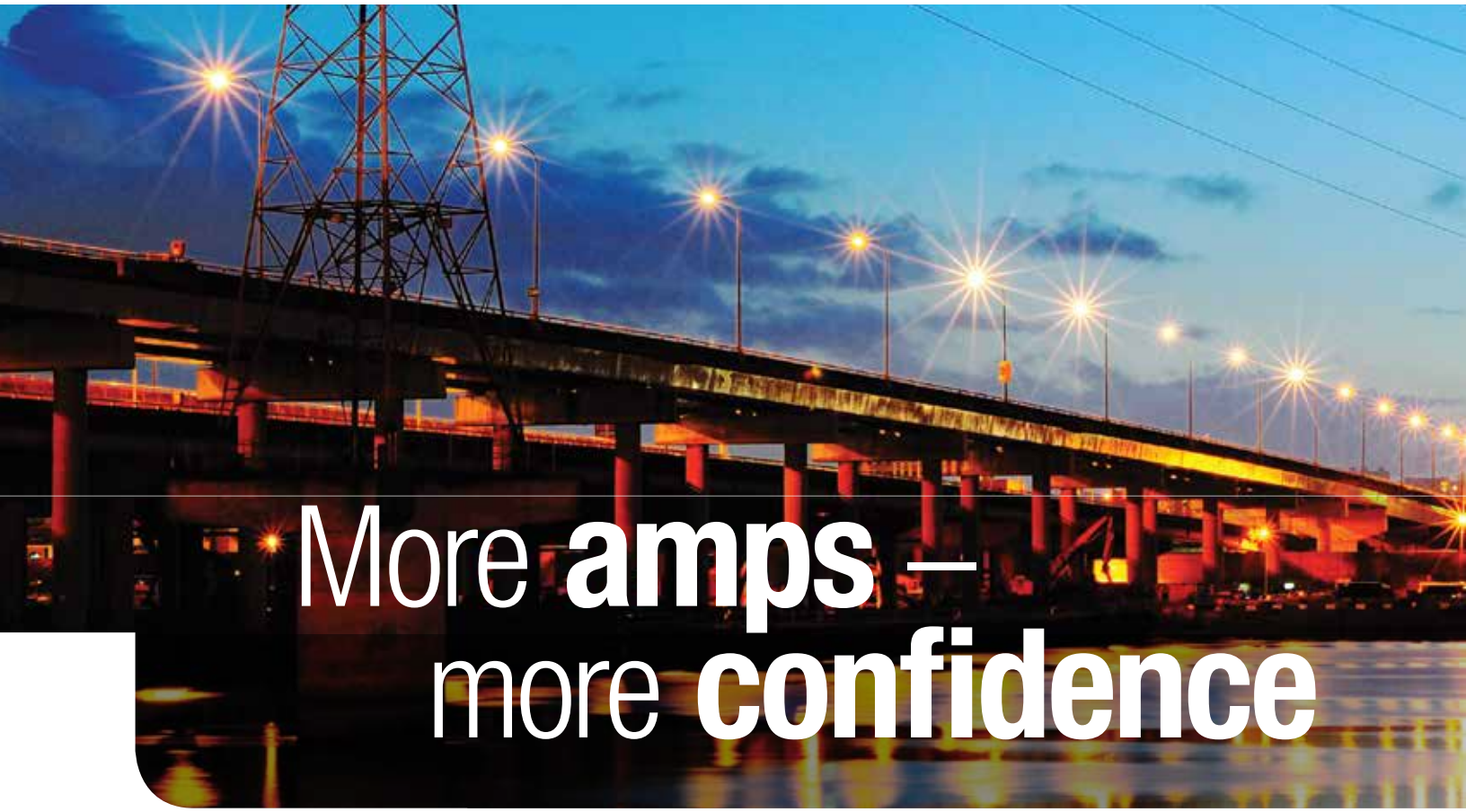
Conductor Core Material	3M™ ACCR Aluminum Matrix	ACSR/ACSS Steel
Strength (ksi)	200	185
Density (lbs/in^3)	0.119	0.282
Strength/Density	1,681	656
Coefficient of Thermal Expansion (10^{-6}/°C)	3.5	6.7

Inside the technology



3M™ ACCR's high-strength, lightweight core is a fiber-reinforced metal matrix, and contains no polymers or plastics.

The aluminum-zirconium outer wires can be heated to high temperatures without softening (annealing). This allows 3M™ ACCR to retain its strength after high temperature operations.



More **amps** – more **confidence**

Maximum ampacity with less sag

Compared to the same diameter steel core conductor, 3M™ ACCR can offer:

- Up to 2 times the ampacity or more
- Less thermal expansion, for less sag at high energy levels
- Higher strength-to-weight ratio
- Operating temperatures up to 210°C continuous and 240°C emergency*

*Emergency operating temperature for up to 1,000 hours cumulative.

Case in point:
A customer serving a major U.S. city upgraded with 3M™ ACCR when, just 4 years after an ACSS upgrade, the line could no longer meet the capacity need.

Long-term reliability

With 3M ACCR, you make no compromises on your tension and clearance standards. Its reliability has been demonstrated around the world, with:

- Large capacity increases at the same clearances, tensions and mechanical loads
- Corrosion resistance without coatings or barriers around the core
- Durability similar to ACSR, even when operated at high temperatures over long periods in extreme environments
- Over a decade of successful, reliable operations

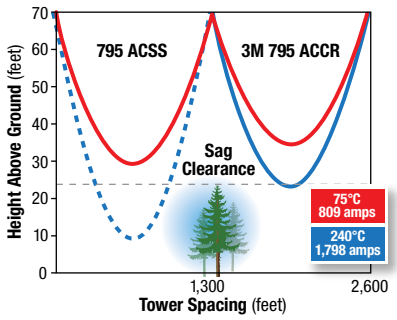
Case in point:
3M™ ACCR is successfully operating in the extreme environments of Siberia and the Hawaiian coast; the heavily populated cities of Shanghai and Washington, D.C.; and the environmentally sensitive Minnesota River Valley and Brazil's Paraná River.

See the installation videos at www.3M.com/accr or at ACCR-YouTube

Fast and easy to use

3M ACCR was designed as a replacement for ACSR and ACSS to quickly and dramatically increase capacity on existing structures – while minimizing lengthy construction and permitting processes. Core stranding, hardware and construction procedures are similar to those for ACSR and are familiar to installers. And with shorter installation times, ACCR can help you get back to service more quickly.

3M™ ACCR significantly increases ampacity without increasing sag



Actual performance may vary depending on a number of variables. The example above assumes ACSS and 3M™ ACCR with a 1,300 ft. ruling span under the following conditions:

Initial Tension of 6,557 lbs at 15ºC, maximum loading at 30ºF, no ice and 12 lbs. of wind; and

Ambient Conditions of 35ºC, 2 ft/s perpendicular wind, 0.5 emissivity and 0.5 solar absorption.

Lower total project cost

By eliminating the need for expensive new towers, land acquisitions and other factors, upgrading with 3M ACCR can offer substantial savings over ACSR and ACSS – even at a higher conductor cost-per-mile. For many thermal upgrades, ACCR can give you the high-performance, cost-effective solution you've been looking for.

3M ACCR Upgrade Cost Comparison Example (Project Cost Per Line Mile)

	Build Parallel Double Circuit Line with ACSS	Upgrade to Double Circuit, Double Bundled with ACSS	Upgrade Double Circuit with 3M ACCR
Conductor[1]	126,000	234,000	584,000
Stringing	126,000	251,000	126,000
Structures[2]	1,150,000	916,000	81,000
Substation Work	335,000	108,000	0
Development[3]	357,000	287,000	108,000
Total	2,094,000	1,796,000	899,000
Construction Time	2 to 5 years	Up to 2 years	4 months during low demand periods
Cost Savings of 3M ACCR	**$1,197,605**	**$898,204**	

Based on costs from U.S. utility projects and represents U.S. costs only.

[1] Includes conductor plus installation accessories.
[2] Includes structures, foundations and labor.
[3] All costs up to start of construction – engineering, land, permitting, procurement, etc.

Case in point:
In the Southwest U.S., a customer reduced their construction outage by 80% using 3M™ ACCR instead of building a parallel line. The project took 4 months, instead of the estimated 20.

Case in point:
A 3M customer analyzed three options – building a new, parallel double circuit line; upgrading the existing double circuit line to double circuit, double bundled; and upgrading the existing line with 3M™ ACCR. Because of the substantial cost and time savings, they met their capacity requirements by reconductoring with ACCR.

Commitment to quality

3M ACCR and its accessories have been rigorously tested and verified to ASTM, IEEE and ANSI specifications, both in the laboratory and in the field. Test conditions included extreme temperatures, heavy icing, heavy loading and corrosive atmospheres. In all cases, 3M ACCR performed up to specifications and showed that the design coefficients accurately predict performance in the field.

To view our complete library of field tests, organized by both conductor size and test subject, visit our website at **www.3M.com/accr**.

Solve your toughest

Tackle the toughest jobs with confidence using 3M™ ACCR!

Changing clearance requirements

NERC reliability standards and clearance requirements over highways, railroads or other shipping lanes may require upgrades. 3M ACCR can provide more capacity with no change in wire diameter or tower load, and often with reduced tension. Because 3M ACCR sags less, line clearances can be significantly improved while delivering the same or greater power, even at high temperatures.

Case in point:
In the U.S. Northwest, ACSR 1780 kcmil running from a generating plant was replaced with a smaller 3M™ ACCR 675 TW that runs frequently at high loads with no operational problems or performance changes.

Densely populated or underbuilt areas

In areas that are densely populated, upgrading with 3M™ ACCR can increase capacity by reusing existing structures with less disruption to the community, and without needing to site new structures. Transmission lines can also be upgraded without having to impact distribution lines underbuilt on the same structures, which means less expense and system disruption.

Case in point:
In a major downtown area, a critical line was upgraded through neighborhoods with many underbuilds. 3M™ ACCR was installed quickly, without disrupting homes or businesses.

Environmentally sensitive areas

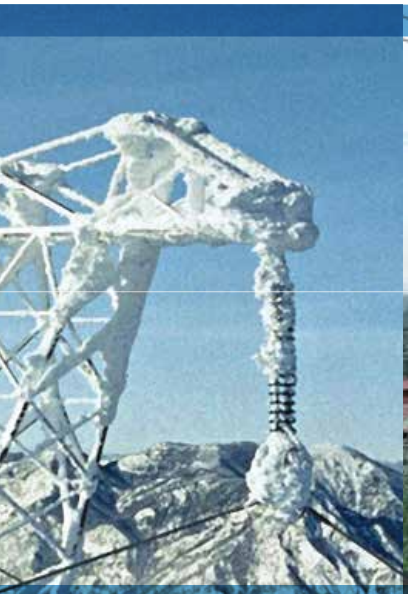
Transmission lines through environmentally sensitive areas require extensive and lengthy reviews and debate before approval. Upgrading with 3M ACCR allows existing structures to be used, avoiding or simplifying those reviews. The appearance of the line does not change.

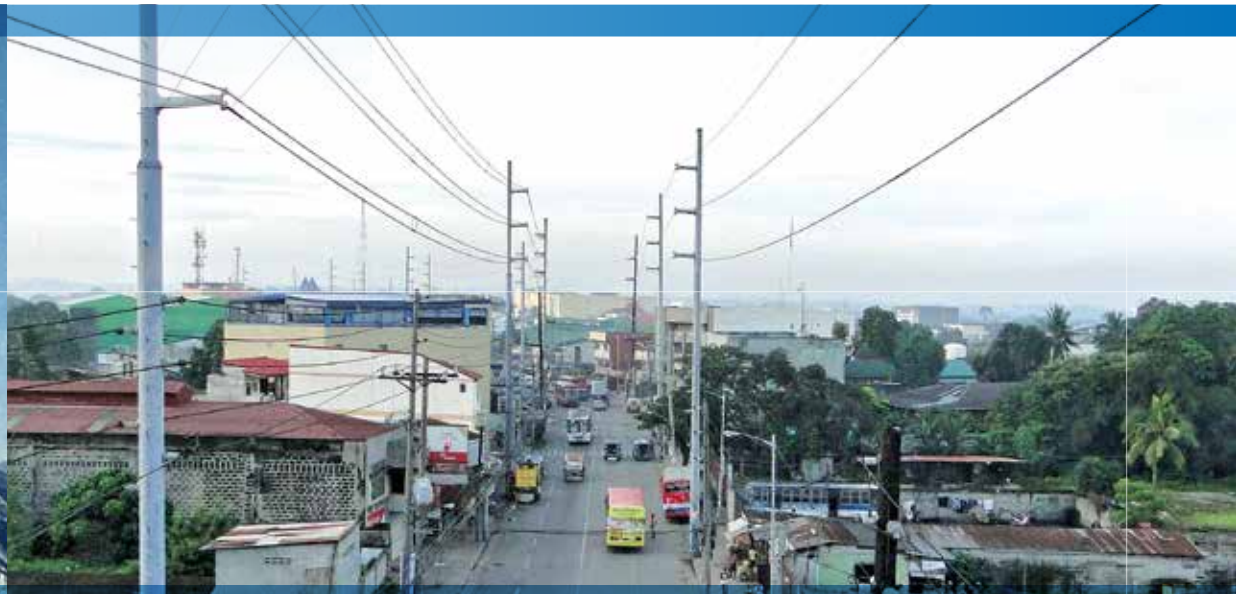
Case in point:
An installation in Minnesota crossed a protected wetland using existing infrastructure and without heavy construction equipment.

Short timelines

3M ACCR can help you avoid construction projects, with their long lead times and permitting delays. Your project could be done faster, relieving constraints and getting the power flowing in record time.

Case in point:
A water crossing in Brazil was installed in just 6 days, compared to the time that would have been required to replace towers and foundations set in the river.





transmission challenges

Long spans/river crossings

Rivers and gorges are among the most difficult challenges, because it may not be possible to put a tower in the middle of the water or to change out existing towers for taller ones. The low sag, high strength and low weight of 3M ACCR can allow longer spans while giving you the capacity increase you need and maintaining or improving clearance and mechanical loads on the existing structures.

Case in point:
3M™ ACCR was used in two 230 kV Canadian installations to cross sensitive waterways. The longest span stretched 5,800 feet (1.7 km) between towers; only existing structures were used.

Heavy ice or wind loads

A high strength-to-weight ratio and modulus make 3M ACCR ideal for areas that experience high mechanical loads such as icing. In some cases, a smaller conductor can be used, reducing the conductor profile and mechanical loads during major wind and ice events. 3M ACCR can increase reliability during demanding loading conditions.

Case in point:
An installation near Fargo, North Dakota has undergone severe wind and icing conditions with no failures, damage to the conductor, or unexpected changes in sag to date.

Corrosive environments

Because both the wire and the core are made from aluminum, 3M ACCR is resistant to corrosive environments such as high-pollution areas or the damp, salty air near seashores. Unlike steel- or carbon-polymer-core conductors, no special coating is required to avoid chemical interaction between the core and the conductor.

Case in point:
An installation in Hawaii has been exposed to one of the most corrosive environments in the world for 11 years, with no corrosion problems.

Watch a video on the Hawaii field test online at 3M.com/accr or at ACCR-YouTube.

3M™ ACCR Round-wire Typical Properties

Strong, lightweight, high capacity conductor

3M™ ACCR conductor is available in a round-wire construction composed of a multi-strand, aluminum-matrix core surrounded by aluminum-zirconium outer wires that are round in shape.

Round-wire, the most commonly used transmission conductor construction, frequently offers the largest capacity increase because of its low weight. This allows it to operate at high temperatures with less sag than steel core conductors and other types of construction, such as trapwire or compact conductors.

Physical Properties	Unit	Ostrich 300	Linnet 336	Hawk 477	Dove 557
Designation		ACCR_297-T16	ACCR_340-T16	ACCR_470-T16	ACCR_573-T16
Stranding		26/7	26/7	26/7	26/7
Diameter					
Individual Core Wire	in	0.083	0.089	0.105	0.116
Individual Aluminum Wire	in	0.107	0.114	0.134	0.149
Total Core	in	0.249	0.267	0.314	0.347
Total Conductor	in	0.677	0.724	0.852	0.941
Area					
Aluminum	in^2	0.233	0.267	0.369	0.450
Total Area	in^2	0.271	0.310	0.429	0.524
Weight					
Core	lbs/ft	0.057	0.065	0.090	0.110
Aluminum	lbs/ft	0.279	0.320	0.443	0.540
Total Weight	lbs/ft	0.337	0.385	0.533	0.650
Strength	lbs	12,100	13,900	19,200	23,100
Thermal Elongation					
Core	10^{-6}/°C	6.3	6.3	6.3	6.3
Aluminum	10^{-6}/°C	23.0	23.0	23.0	23.0
Total Conductor	10^{-6}/°C	16.7	16.7	16.7	16.7
Heat Capacity					
Core	W-sec/ft-°C	22	25	35	43
Aluminum	W-sec/ft-°C	121	139	192	234
Electrical Properties					
Resistance					
DC @ 20°C	ohms/mile	0.2939	0.2568	0.1855	0.1522
AC @ 25°C	ohms/mile	0.3004	0.2626	0.1901	0.1562
AC @ 50°C	ohms/mile	0.3301	0.2885	0.2087	0.1715
AC @ 75°C	ohms/mile	0.3597	0.3144	0.2274	0.1868
AC @ 100°C	ohms/mile	0.3894	0.3403	0.2461	0.2021
AC @ 210°C	ohms/mile	0.5199	0.4544	0.3284	0.2695
AC @ 240°C*	ohms/mile	0.5555	0.4855	0.3509	0.2879
Geometric Mean Radius	ft	0.0229	0.0245	0.0288	0.0318
Reactance (1 ft spacing, 60 hz)					
Inductive Xa	ohms/mile	0.458	0.450	0.430	0.418
Capacitive X'a	Mohms-mile	0.1059	0.1039	0.0990	0.0961
Ampacity					
210°C	amps	864	944	1169	1332
240°C*	amps	926	1012	1255	1432

* Emergency operating temperature, 1000 hours cumulative over the life of the conductor.

Ampacity ratings were calculated using IEEE Std. 738-2006, with inputs of 40°C (104°F) air temperature; 2.0 ft/s wind speed (at 90° angle between wind and conductor); elevation at sea level; solar radiation at 92.499 Watt/ft^2; emissivity of 0.5 and solar absorptivity of 0.5.

Grosbeak 636	Drake 795	Curlew 1033	Bittern 1272	Martin 1351	Lapwing 1590
ACCR_656-T16	ACCR_824-T16	ACCR_1036-T13	ACCR_1238-T11	ACCR_1334-T13	ACCR_1594-T11
26/19	26/19	54/19	51/19	54/19	51/19
0.074	0.083	0.083	0.083	0.094	0.094
0.159	0.178	0.139	0.156	0.157	0.177
0.371	0.416	0.416	0.416	0.472	0.472
1.006	1.128	1.247	1.350	1.415	1.532
0.515	0.648	0.814	0.972	1.048	1.252
0.597	0.751	0.917	1.075	1.180	1.385
0.122	0.153	0.153	0.153	0.197	0.197
0.617	0.777	0.980	1.172	1.262	1.509
0.740	0.930	1.134	1.325	1.460	1.706
25,600	32,200	35,600	38,500	45,300	49,500
6.3	6.3	6.3	6.3	6.3	6.3
23.0	23.0	23.0	23.0	23.0	23.0
16.5	16.5	17.1	17.8	17.1	17.8
48	60	61	61	78	78
267	336	424	507	546	653

0.1333	0.1060	0.0859	0.0725	0.0667	0.0563
0.1371	0.1095	0.0895	0.0764	0.0705	0.0605
0.1505	0.1201	0.0980	0.0835	0.0770	0.0659
0.1638	0.1307	0.1066	0.0906	0.0836	0.0714
0.1772	0.1413	0.1151	0.0978	0.0902	0.0769
0.2363	0.1882	0.1530	0.1296	0.1193	0.1013
0.2524	0.2009	0.1633	0.1383	0.1273	0.1080
0.0340	0.0381	0.0421	0.0453	0.0477	0.0514
0.410	0.396	0.384	0.376	0.369	0.360
0.0941	0.0907	0.0877	0.0854	0.0840	0.0816
1454	1691	1939	2162	2289	2551
1563	1821	2089	2332	2470	2756

Conformance to National Standards

All materials shall conform to the applicable American National Standards Institute (ANSI) C119.4; American Society for Testing and Materials (ASTM) Standards B193, B976, B941; or International Annealed Copper Standard (IACS).

Physical Properties	Unit	Hawk 477TW	Calumet	Oswego	Wabash
Diameter Equivalent Roundwire			**Hawk**	**Dove**	**Grosbeak**
Designation		ACCR-TW_477-T16	ACCR-TW_565-T17	ACCR-TW_665-T16	ACCR-TW_763-T17
Stranding		18/7	20/7	20/19	20/19
Diameter					
Individual Core Wire	in	0.105	0.116	0.074	0.083
Individual Aluminum Wire	in	N/A	N/A	N/A	N/A
Total Core	in	0.314	0.347	0.371	0.416
Total Conductor	in	0.789	0.861	0.919	0.990
Area					
Aluminum	in^2	0.375	0.444	0.522	0.599
Total Area	in^2	0.435	0.517	0.604	0.702
Weight					
Core	lbs/ft	0.090	0.110	0.123	0.154
Aluminum	lbs/ft	0.448	0.530	0.624	0.716
Total Weight	lbs/ft	0.538	0.640	0.747	0.870
Strength	lbs	19,100	23,000	25,800	31,200
Thermal Elongation					
Core	10^{-6}/°C	6.3	6.3	6.3	6.3
Aluminum	10^{-6}/°C	23.0	23.0	23.0	23.0
Total Conductor	10^{-6}/°C	16.8	16.6	16.5	16.2
Heat Capacity					
Core	W-sec/ft-°C	35	43	48	60
Aluminum	W-sec/ft-°C	194	230	270	310

Conductor Electrical Properties					
Resistance					
DC @ 20°C	ohms/mile	0.1825	0.1537	0.1311	0.1135
AC @ 25°C	ohms/mile	0.1870	0.1578	0.1348	0.1170
AC @ 50°C	ohms/mile	0.2054	0.1733	0.1480	0.1284
AC @ 75°C	ohms/mile	0.2238	0.1888	0.1612	0.1398
AC @ 100°C	ohms/mile	0.2422	0.2043	0.1744	0.1512
AC @ 210°C	ohms/mile	0.3231	0.2724	0.2324	0.2015
AC @ 240°C*	ohms/mile	0.3452	0.2910	0.2483	0.2152
Geometric Mean Radius	ft	0.0268	0.0291	0.0311	0.0338
Reactance (1 ft spacing, 60 hz)					
Inductive Xa	ohms/mile	0.439	0.429	0.421	0.411
Capacitive X'a	Mohms-mile	0.1013	0.0987	0.0968	0.0946
Ampacity					
210°C	amps	1150	1288	1424	1566
240°C	amps	1234	1383	1530	1684

* Emergency operating temperature, 1000 hours cumulative over the life of the conductor.

Because the trapezoidal shape of the outer wires incorporates more aluminum, the weight and sag may increase slightly compared to diameter-equivalent round wire designs. Your 3M representative can help you choose the optimal combination of conductor properties for your application.

Ampacity ratings were calculated using IEEE Std. 738-2006, with inputs of 40°C (104°F) air temperature; 2.0 ft/s wind speed (at 90° angle between wind and conductor); elevation at sea level; solar radiation at 92.499 Watt/ft^2; emissivity of 0.5 and solar absorptivity of 0.5.

3M™ ACCR Trapwire Typical Properties

Higher conductivity in higher amp applications

3M brings its reputation for reliability to trapwire conductors, offering a full line with diameters comparable to standard conductors.

Trapwire designs replace the round outer wires of the conductor with trapezoidal-shaped wires, in order to maximize the amount of current-carrying aluminum within the same total diameter. The result is an increase in conductivity that may reduce resistive losses on the line. Work with your 3M representative to choose the best solution for your application, considering your capacity needs and the characteristics of your specific project.

Suwanee	Curlew 1033 TW	Hudson	Pecos	Cumberland
Drake		**Cardinal**	**Martin**	**Falcon**
ACCR-TW_958-T16	ACCR-TW_1033-T13	ACCR-TW_1158-T13	ACCR-TW_1622-T13	ACCR-TW_1927-T13
24/19	20/19	24/19	38/19	38/19
0.089	0.083	0.089	0.105	0.116
N/A	N/A	N/A	N/A	N/A
0.445	0.416	0.445	0.523	0.578
1.099	1.132	1.199	1.411	1.551
0.752	0.811	0.909	1.274	1.513
0.870	0.914	1.027	1.437	1.713
0.176	0.154	0.176	0.243	0.296
0.899	0.969	1.087	1.531	1.819
1.075	1.123	1.263	1.774	2.115
37,000	35,600	40,300	55,500	66,600
6.3	6.3	6.3	6.3	6.3
23.0	23.0	23.0	23.0	23.0
16.5	17.3	17.3	17.1	17.0
69	60	69	96	117
389	420	470	662	786
0.0910	0.0854	0.0761	0.0547	0.0460
0.0943	0.0889	0.0796	0.0584	0.0499
0.1034	0.0974	0.0871	0.0637	0.0543
0.1125	0.1059	0.0947	0.0690	0.0587
0.1216	0.1145	0.1023	0.0744	0.0632
0.1618	0.1522	0.1358	0.0983	0.0831
0.1728	0.1625	0.1450	0.1048	0.0886
0.0369	0.0376	0.0396	0.0468	0.0514
0.400	0.398	0.392	0.372	0.360
0.0915	0.0906	0.0889	0.0841	0.0813
1808	1883	2031	2519	2821
1946	2027	2187	2719	3048

Conformance to National Standards

All materials shall conform to the applicable American Society for Testing and Materials (ASTM) Standards B193, B976, B941; or International Annealed Copper Standard (IACS).

Expert technical support

From the lab to the field, 3M's global technical resources are working to help your project run smoothly from start to finish. Our highly qualified and experienced technical team can help you find the best solution for your unique application, providing assistance in:

- Balancing capacity, efficiency, mechanical, clearance, economic and environmental objectives
- Evaluating line characteristics to define the right mix of conductor and accessories
- Comparing options in PLS-CADD™, SAG10™ and other design software
- Supporting your installation crew with training and consultation

For more information, contact our technical team at **800-364-3577** or **accr@mmm.com**, or visit our website at **www.3M.com/accr**.

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