A is for ~~Apple~~ Arbutus
B is for ~~Ball~~ Bittern

Manufacturing Standards for North American Bare Overhead Conductors

by
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General Cable

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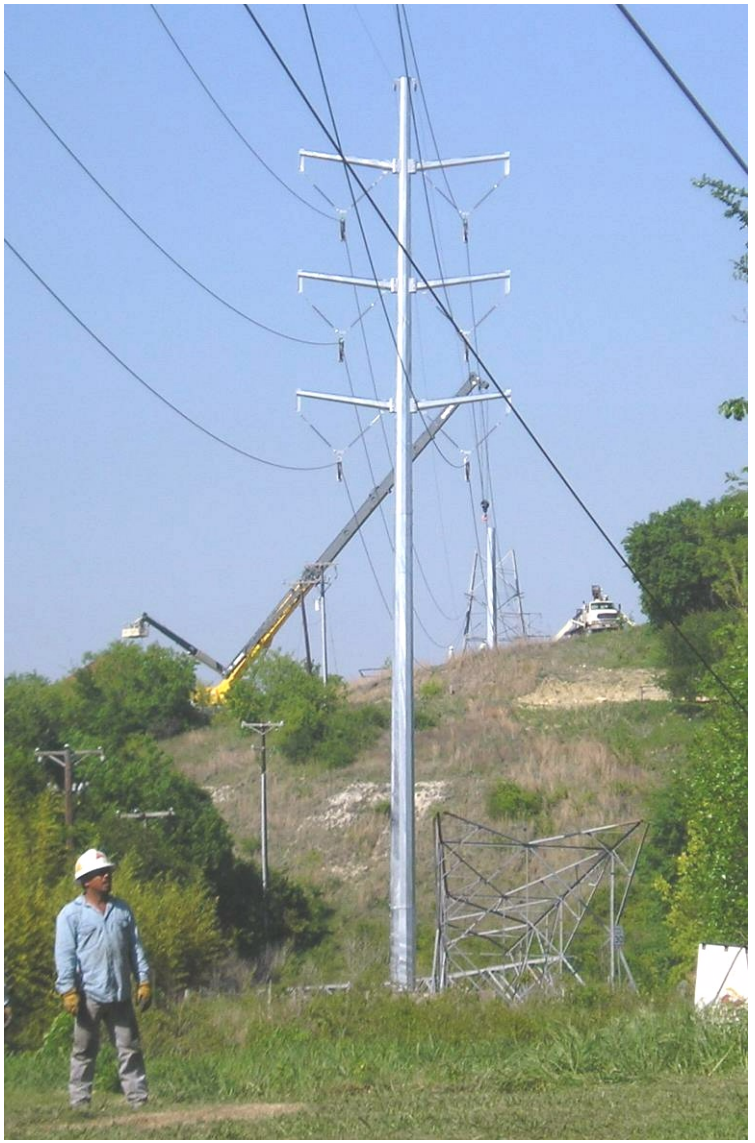
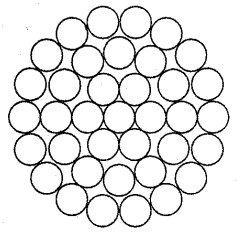
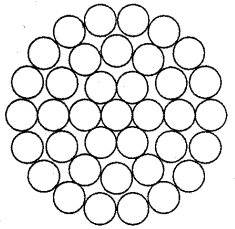


CODE WORD names



- Electrical conductors have a unique naming system that is used to identify the **construction details** for bare and 600V rated products.
  example - ACSR conductors use “bird” names.
  - AAC conductors use “flower” names.
  - AAAC conductors use names of “cities”.
- For US and Canada, The Aluminum Association publication #50 provides a listing of these names for Overhead products.
- Code word names can be modified using suffix modifiers - Drake/ACSS/HS, or Orchid/TW

Conductor Design Standards



- ASTM International Standards = USA

  - fall under the jurisdiction of the B1 committee
  - 19 individual specifications for bare overhead electrical conductors.
- CSA International = Canada

  - CSA C49.x + CAN/CSA C6xxxx family of modified IEC standards
  - fall under the jurisdiction of the CSA Technical Committee on Overhead Conductors.
  - 4 individual specifications for stranded bare overhead electrical conductors

19 ASTM standards for OVERHEAD CONDUCTORS.

- ASTM B8 Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
- ASTM B228 Standard Specification for Concentric-Lay-Stranded Copper-Clad Steel Conductors
- ASTM B229 Standard Specification for Concentric-Lay-Stranded Copper and Copper-Clad Steel Composite Conductors
- ASTM B231/B231M Standard Specification for Concentric-Lay-Stranded Aluminum 1350 Conductors
- ASTM B232/B232M Standard Specification for Concentric-Lay-Stranded Aluminum Conductors, Coated-Steel Reinforced (ACSR)
- ASTM B233 Standard Specification for Aluminum 1350 Drawing Stock for Electrical Purposes
- ASTM B399/B399M Standard Specification for Concentric-Lay-Stranded Aluminum-Alloy 6201-T81 Conductors
- ASTM B400 Standard Specification for Compact Round Concentric-Lay-Stranded Aluminum 1350 Conductors
- ASTM B401 Standard Specification for Compact Round Concentric-Lay-Stranded Aluminum Conductors, Steel-Reinforced (ACSR/COMP)
- ASTM B416 Standard Specification for Concentric-Lay-Stranded Aluminum-Clad Steel Conductors
- ASTM B524/B524M Standard Specification for Concentric-Lay-Stranded Aluminum Conductors, Aluminum-Alloy Reinforced (ACAR, 1350/6201)
- ASTM B549 Standard Specification for Concentric-Lay-Stranded Aluminum Conductors, Aluminum-Clad Steel Reinforced (ACSR/AW)
- ASTM B701/B701M Standard Specification for Concentric-Lay-Stranded Self-Damping Aluminum Conductors, Steel Reinforced (ACSR/SD)
- ASTM B711 Standard Specification for Concentric-Lay-Stranded Aluminum-Alloy Conductors, Steel Reinforced (AACSR) (6201)
- ASTM B778 Standard Specification for Shaped Wire Compact Concentric-Lay-Stranded Aluminum Conductors (AAC/TW)
- ASTM B779 Standard Specification for Shaped Wire Compact Concentric-Lay-Stranded Aluminum Conductors, Steel-Reinforced (ACSR/TW)
- ASTM B856 Standard Specification for Concentric-Lay-Stranded Aluminum Conductors, Coated Steel Supported (ACSS)
- ASTM B857 Standard Specification for Shaped Wire Compact Concentric-Lay-Stranded Aluminum Conductors, Coated-Steel Supported (ACSS/TW)
- ASTM B911/B911M Standard Specification for ACSR Twisted Pair Conductor (ACSR/TP)

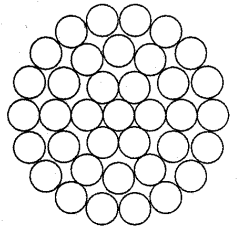
- ~~ASTM B397 Standard Specification for Concentric-Lay-Stranded Aluminum-Alloy 5005-H19 Conductor~~s (Withdrawn 2004) No Replacement

4 CSA standards for OVERHEAD CONDUCTORS.

- CAN/CSA-C61089:03 Round Wire Concentric Lay Overhead Electric Stranded Conductors
  for round wire concentric lay overhead electrical conductors and contains many different conductor types
- ~~C49.1 – M87 Round Wire, Concentric Lay Overhead Electrical Conductors~~
  This standard was withdrawn in May 2004 and replaced by CAN/CSA C61089:03
- C49.2 – 1975 R2004 Compact Aluminum Conductors Steel Reinforced (ACSR)
- ~~C49.4 1978 R1999 Concentric Lay Aluminum Stranded Conductors (ASC)~~
  This standard was withdrawn in March 2004 and replaced by CAN/CSA C61089:03
- C49.5 - 1978 R2004 Compact Round Concentric Lay Aluminum Stranded Conductors
- G12 – 1992 R2000 Zinc Coated Steel Wire Strand

- Canadian standards have moved / are moving to utilize the International Electrotechnical Commission (IEC) based standards and will include "Country Specific" deviations. The main IEC overhead conductor specification is IEC 61089.
- IEC is introducing a new omni-bus standard that will expand the conductor types to include for example, ACSS, Compact, and TW conductor designs.

Conductor Designs



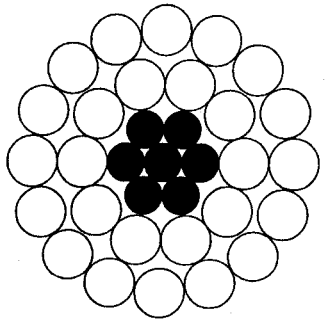
- Catalogs have hundreds of conductor sizes and constructions.
- All conductor designs are based on simple mathematical equations that dictate the size and geometry of the conductor.
- Anyone can design a conductor…

$$795\ Arbutus = \frac{795{,}000\ cmil}{37\ wires} = 21486\ cmil\ \ per\ \ wire$$

$$diameter\ of\ \ each\ \ wire = \sqrt{21486} = 146.6\ mil = 0.1466\ "$$

Conductor Designs

- ACSR designs have a few extra steps…



Drake is a $26/7$ *construction.*

$$795\ Drake = \frac{795{,}000\,cmil}{26\ wires} = 30577\ cmil\ \ per\ \ wire$$

$$diameter\ of\ each\ wire = d_a = \sqrt{30577} = 174.9\,mil = 0.1749"$$

There are 10 *Alum strand wires in the inner layer* $(n = 10)$ *and* 16 *wires in the outer layer.*
There are 7 *Steel strand wires in the core;*

$$The\ calculated\ diameter\ of\ the\ steel\ core = D_s = \frac{d_a \text{ x } (n-3)}{3} = \frac{0.1749" \text{ x } (10-3)}{3} = 0.4081"$$

$$The\ diameter\ of\ a\ 7\ wire\ steel\ core = 3 \text{ x } D_s$$

$$The\ size\ of\ the\ individual\ steel\ core\ wire = \frac{0.4081"}{3} = 0.1360"$$

$$The\ 795\,kcmil = 26 \times 0.1749"\ alum\ strands\ \ \ over\ \ \ 7 \times 0.1360"\ steel\ strands$$

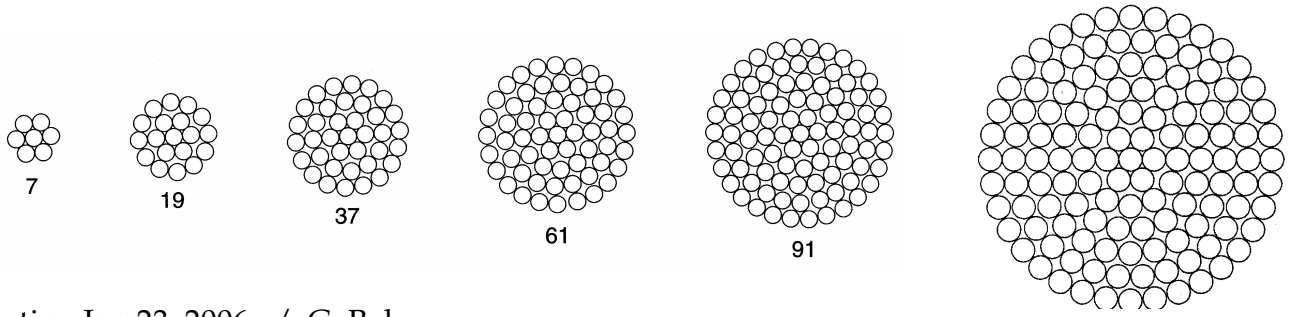
AAC or A1 Type Conductors

- **AAC** is an **A**ll **A**luminum **C**onductor and built with hard drawn 1350 Aluminum (ASTM B231)

  (code word names are flowers – example: TULIP)

- **A1** is what used to be called an **ASC** (**A**luminum **S**tranded **C**onductor). It is built with hard drawn 1350 Aluminum (CAN/CSA C61089)

  (A1 still uses flower code word names - eg TULIP)
  (also identified using IEC method of identifying the equivalent electrical mm^2 area, aluminum alloy designation, and number of strands – example: 336.4 kcmil TULIP = 170-A1-19)

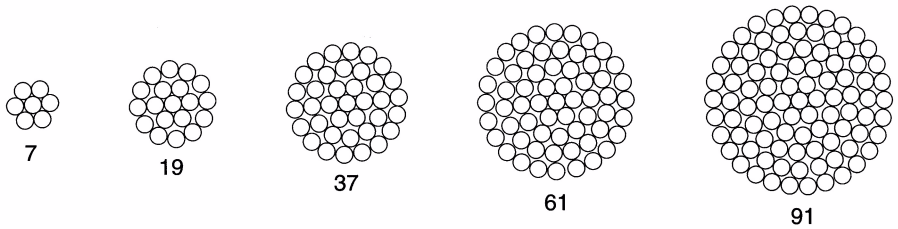


AAAC or A2 or A4 Type Conductors

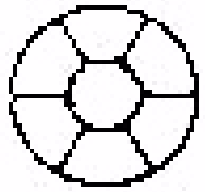
- **AAAC** is an **A**ll **A**luminum **A**lloy **C**onductor and built with 6201 Aluminum-Magnesium-Silicon Alloy Aluminum.(ASTM B399) **(code word names are US cities – example: AKRON)**

- **A2** and **A4** are what used to be called **AASC (**Aluminum **A**lloy **S**tranded **C**onductor). It is built with 6101 Aluminum-Magnesium-Silicon Alloy Aluminum. A2 and A4 differ in conductivity and strength properties . (CAN/CSA C61089)

  (A2 uses Canadian city code word names – example Halifax) (also identified using IEC method of identifying the equivalent electrical 1350 mm^2 area, aluminum alloy designation, and number of strands – example 123.4mm2 (7 wire) A2 conductor would be shown as 107-A2-7)



Aluminum Compact Conductors



- **AAC** /compact is an compact round **A**ll **A**luminum **C**onductor and built with hard drawn 1350 Aluminum (ASTM B400)
  (code word names modified by term "compact")

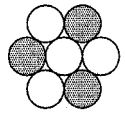
- **ASC/SB** is a **S**mooth **B**ody **A**luminum **S**tranded **C**onductor and built with hard drawn 1350 Aluminum (CSA C49.5)
  (there are Reptile code word names eg Gecko)

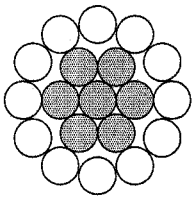
- **Do not confuse these designs with TW (Trapezoidal) conductors.**

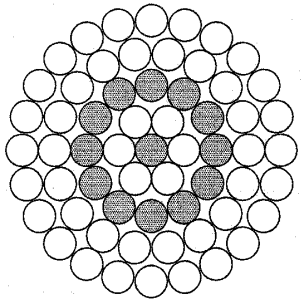
ACAR Conductors

- **ACAR** is an **A**luminum **C**onductor **A**lloy Aluminum **R**einforced conductor built with hard drawn 1350 aluminum and 6201 Aluminum-Magnesium-Silicon Alloy Aluminum. (ASTM B524)
- **ACAR** is built with a variety of different 1350/6201 strand configurations. The higher the percentage 6201 content, the greater the strength of the conductor.

  (note - ACAR does not have code word names)
- **ACAR** is identified by total aluminum kcmil area and the number of 1350/6201 strand wires
  example: 500 kcmil (12/7) ACAR

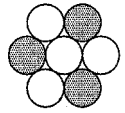




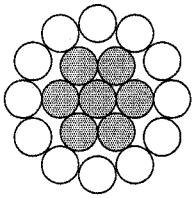


A1/A2 or A1/A4 Conductors

- **A1/A21 or A1/A4** are similar to the ACAR type of conductor, except it utilizes the 6101 T81 or 6101 T83 aluminum alloy in place of 6201.

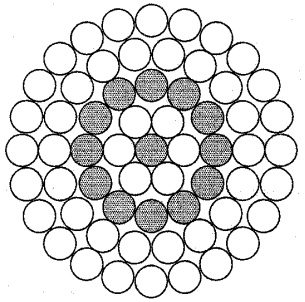


- **A1/A2 or A1/A4** are built with a variety of different 1350/6101 strand configurations. The higher the percentage 6101 content, the greater the strength of the conductor.



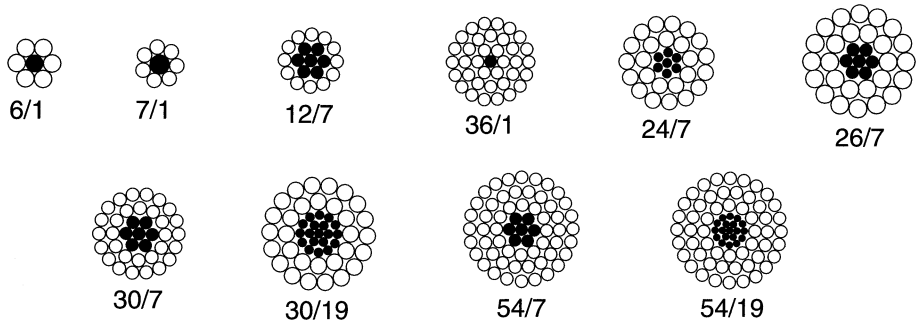
(these conductors do not have code word names)

- Conductors are identified by total equivalent 1350 electrical mm^2 area and the number of 1350/6101 strand wires. Example: 100-A1/A2-4/3 for a conductor consisting of 4 x 1350 strands ($60.55mm^{2)}$ plus 3 x 6101-T83 strands ($45.51mm^2$).



ACSR Conductors

- **ACSR** is an **A**luminum **C**onductor **S**teel **R**einforced conductor built with hard drawn 1350 aluminum and a coated steel core.
- In the USA = ASTM B232 specification
- **ACSR** is built with a wide range of percentage steel content. The higher the steel content the greater the strength of the conductor. **(code word names are birds - PARTRIDGE)**



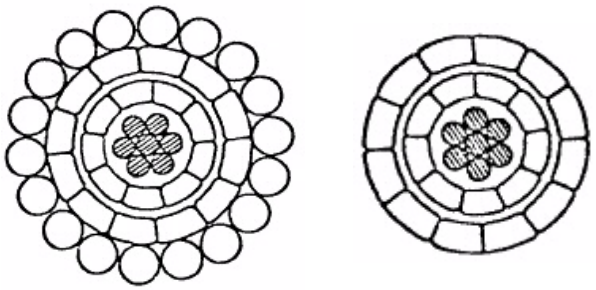
A1/SxA ACSR Conductors

- In Canada ACSR is built to the CAN/CSA C61089 specification
- While the stranding wire sizes may be identical to US ACSR, there are differences between CSA and ASTM designs
  a) strength of the steel core material (3 grades not 2)
  b) use a different method to calculate the rated strength
  c) have different nominal stranding increment mass and resistance increase factors
  d) CSA does not recognize as wide of a proliferation of steel core options that ASTM offers.
- "bird" code word names are still commonly referred to, however the "correct" method to identify the conductors is by stating the total 1350 electrical mm2 area, the grade and strength of steel core, and the number of strand wires
  - example:

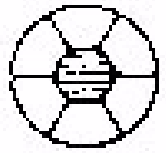
  266.8 kcmil (135.2 mm^2) Partridge = 135-A1/S1A-26/7

Self Dampening ACSR Conductors

- **ACSR/SD** is an **ACSR** conductor built such that there is a gap between the inner TW layers of aluminum, and between the TW aluminum and the steel core. (ASTM B701)
- SD conductors are not as popular as they once were. Their continued use is limited.
- **(use the code word names modified by suffix "SD")**



Compact ACSR Conductors



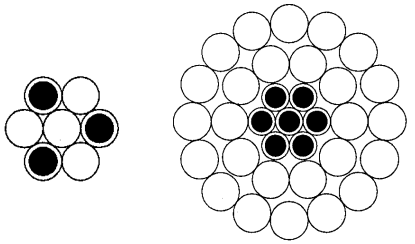
- **ACSR/COMP** is a compact **A**luminum **C**onductor **S**teel **R**einforced conductor built with hard drawn 1350 aluminum and a coated steel core. (ASTM B401)
  (code word names modified by term "compact")

- **ACSR/SB** is a **S**mooth **B**ody **ACSR** Conductor and built with hard drawn 1350 Aluminum (CSA C49.2)
  (there are unique Fish code word names)

Type 100 Type 150 Type 200

- **Do not confuse these designs with TW (Trapezoidal) conductors.**

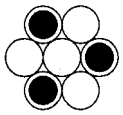
ACSR/AW Conductors



- **ACSR/AW** is built with a variety of different 1350/AW strand configurations. The higher the percentage AW content, the greater the strength of the conductor. (ASTM B549)
- the "**AW"** designation = Aluminum Clad Steel
- Code word names are used for an ACSR conductor that is using AW steel instead of regular steel. The code word name is modified with the suffix "AW".
  - example: PARTRIDGE/AW
- **AWAC®** is a common name used for a number of ACSR/AW constructions (Also in ASTM B549)

  * AWAC is a registered trade name of US Alumoweld

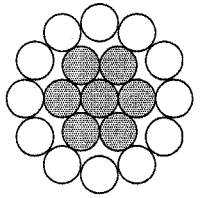
ACSR/AW Conductors



- **AWAC®** is a common name used for a number of ACSR/AW constructions
  * AWAC is a registered trade name of US Alumoweld
- The "sizing" of AWAC can lead to confusion. The conductor construction is built to match the equivalent dc electrical conductivity of an all aluminum conductor.
- the "AWAC" conductors call out an "equivalent" AWG size and the number of Aluminum/ AW strand wires.

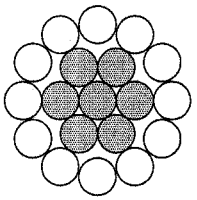
  –example: 2/0 AWAC (4/3) = approximately 120.2 kcmil total aluminum = 4 x .1674" 1350H19 + 3 x .1674" AW steel wires. (2/0 AWG 7w 1350 = 133.1 kcmil aluminum..)
- to avoid confusion with the conductor design, it is suggested to always reference an overall outside diameter.

AACSR Conductors



- **AACSR** is is an **A**luminum **A**lloy **C**onductor **S**teel Reinforced conductor built with 6201 aluminum and a coated steel core. (ASTM B711)
- Steel core can be AW, GA, HS, MA, AZ, etc.
- The conductor is described by overall mm^2 area of the aluminum, aluminum alloy type, and the stranding, along with the strength grade and type of steel suffix.
  – example:
  for a 3/0 6101-T81 AACSR made with high strength zinc galvanized steel = 97-A2/S2A-6/1 AACSR/HS

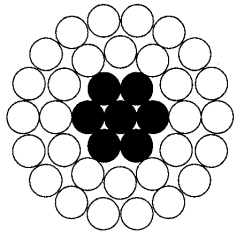
A2/SxA (AACSR) Conductors



- **AACSR** is an **A**luminum **A**lloy **C**onductor **S**teel **R**einforced conductor built with A2 (6101 T81) or A4 (6101 T83) aluminum alloy and a coated steel core. (CAN/CSA C61089)
- Steel core can be S1A, S2A, S3A, etc.
- The conductor is described by overall mm^2 area of the aluminum, aluminum alloy type, and the stranding, along with the strength grade and type of steel suffix.

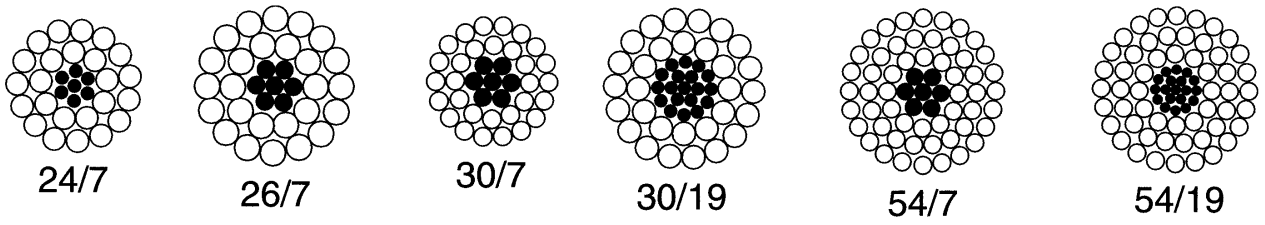
  example: for a 3/0 6101-T81 AACSR made with high strength zinc galvanized steel = 97-A2/S2A-6/1

ACSS Conductors

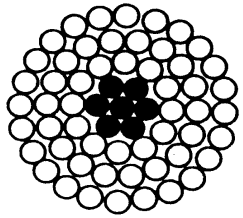


- ACSS is an **A**luminum **C**onductor **S**teel **S**upported conductor built with **annealed** 1350 aluminum and a coated or clad steel core. (ASTM B856)
- ACSS is built with a wide range of percentage steel content. The higher the steel content the greater the strength of the conductor.

(code word name modified by /ACSS - "DRAKE/ACSS")



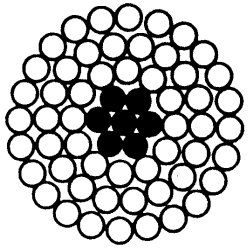
ACSR & ACSS Steel Core



Steel Core Coatings & Strength Ratings

- **GA** for regular strength, Class A galvanized steel (ASTM B498) (most common)
- **GC** for regular strength, Class C galvanized steel (ASTM B498) (offering better corrosion)
- **HS** for High Strength galvanized steel (ASTM B606)
- **AW** for aluminum clad steel (ASTM B502)
- **MA** for mischmetal (Zn-5Al-MM) coating (ASTM B802)
- **MS** for High Strength mischmetal coating (ASTM B803)
- **UHS?** + **UMS?** – new ASTM standards being developed to address the option of using Ultra High Strength steel (B01.05 - TG 25 WK 8132 and TG 26 WK 8133).
- **(code word name modified to show steel type "DRAKE/HS", "CONDOR/ACSS/TW/MA")**

ACSR Steel Core



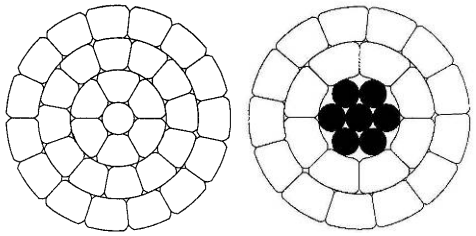
Steel Core Coatings & Strength Ratings

- **S1A** for regular strength, Class A galvanized steel (CAN/CSA C60888)
- **S2A** for high strength, Class A galvanized steel (CAN/CSA C60888)
- **S3A** for extra high strength, Class A galvanized steel (CAN/CSA C60888)
- **S1C** for regular strength, Class C galvanized steel (CAN/CSA C60888)
- **NOTE** = CSA "S2A" ≡ ASTM "GA"
  CSA "S3A" ≡ ASTM "HS"
- IEC (and eventually CSA) is introducing a new standard that will expand the types of steel core materials to include for example the "equivalent" of MA, MS, AW, and Invar.

Twisted Pair Conductors

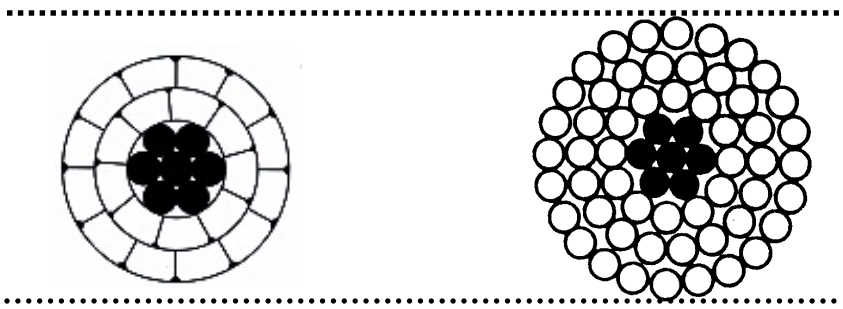
- **ACSR TP** is two regular ACSR conductors twisted together with one complete twist every 9 feet. (ASTM B911)
- Conductor is used throughout central USA as a means to control aeolian vibration and galloping concerns.
- **AAC TP**, while not as common is also built.

Trapezoidal Conductors



- Trapezoidal Conductors use the suffix "**TW**"
- The aluminum strands are shaped to provide a more compact conductor. The strand wires are pre-shaped prior to stranding so they fit together and reduce the interstitial empty spaces. Think of the trapezoidal shapes as "paving stones" that are tightly fit together.
- TW conductors are built to a number of ASTM standards
  AAC/TW = ASTM B778 (code words = flowers and mountains)
  ACSR/TW = ASTM B779 (code words = birds and rivers)
  ACSS/TW = ASTM B857 (code words = birds and rivers)

Trapezoidal Conductors (/TW)



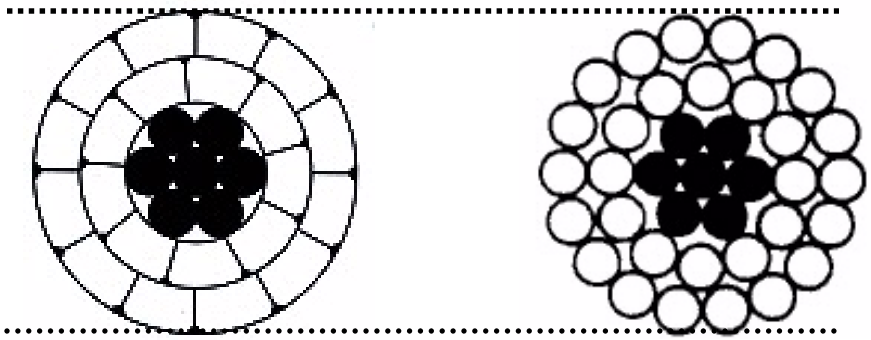
Design Option #1 - SMALLER OVERALL DIAMETER

The conductor on the left is an example of a trapezoidal conductor that has the same aluminum cross- sectional area as the conventional conductor on the right, but has a smaller overall diameter.

The smaller diameter means lower ice and wind loading factors. This enables a reduction in the design strength requirements for the towers and poles.

The equivalent TW conductor is approximately 10% smaller in OD.

Trapezoidal Conductors (/TW)

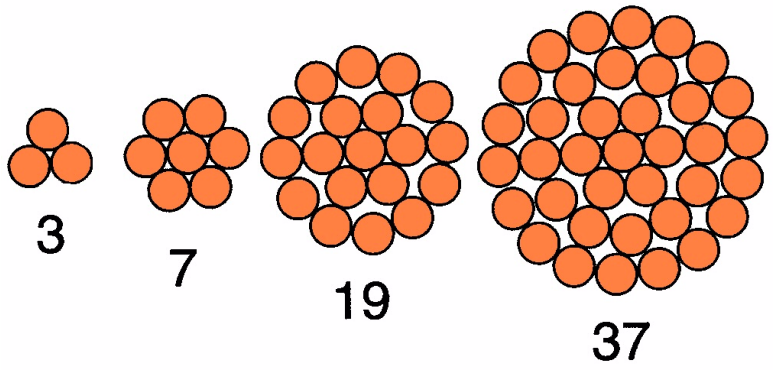


Design Option #2 - SAME DIAMETER - more kcmil ALUMINUM

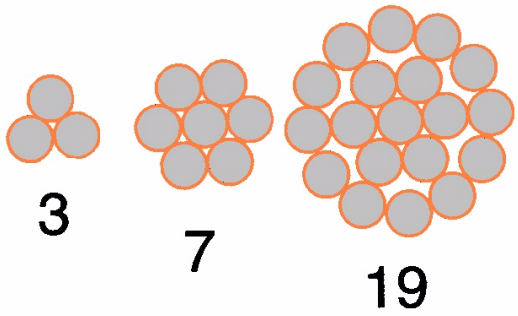
The conductor on the left is an example of a trapezoidal conductor that has a much larger aluminum cross-sectional area than the conventional conductor on the right, while having the same overall diameter. You can increase the Aluminum content >20-25% and significantly increase the current carrying capacity of the line.

Copper Conductors

- **Copper Conductors are** built with hard drawn copper (ASTM B8).
- There are no code word names for copper overhead conductors.

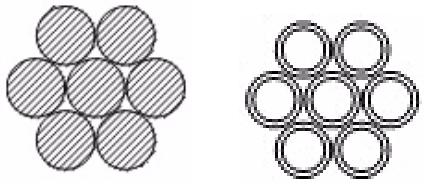


Copper Clad Steel



- **Copper Clad Steel Conductors** are built with hard drawn copper clad steel wires. (ASTM B228).
- There are no code word names for copper overhead conductors.
- Copperweld® is a common name used.
  * Copperweld is a registered trade name of US Alumoweld
- an example of the conductor identification would be - Grade 30HS 7 #8 corresponding to a 7 wire strand of #8 size High Strength copper clad steel, with each wire having a nominal 30% IACS conductivity.

Guy Wire and Sky Wire



- 3, 7 + 19 wire constructions
- Galvanized Steel and Aluminum Clad Steel designs

- **ASTM A475** for galvanized steel strand used for guy wire, messengers, and sky wire (5 strength grades)
  eg 3/8” 7 wire EHS (extra high strength)

- **CSA G12** for galvanized steel strand used for guy wire, messengers, and sky wire (4 strength grades)
  eg Grade 1100 9 mm 7 wire

- **ASTM B416** for aluminum clad steel used for “electrical purposes” (1 strength grade and 20.3% IACS conductivity) Similar to Alumoweld’s® “M”designation guy wire
  eg ASTM B416 7 x #9AWG ≈ 12.5M
  ASTM B416 7 #11 AWG ≈ 8M

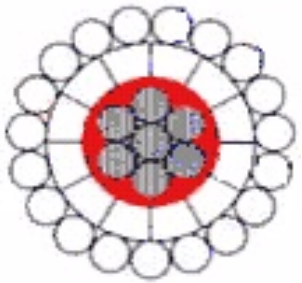
Non Specular Finish

- Aluminum conductors can be supplied with a "Non-Specular" or "De-Glared" surface.
- (sometimes code word name modified with "/NS" designation)
- ANSI C7.69-1976 (R1982) and Aluminum Association Publication AAC7.69-1996. (both are old spec's and technically obsolete….)

"NEW" Conductor Designs

- **GTACSR Gap AlZr ACSR**
- **GTZACSR Gap AlZr ACSR**
- **ZTACIR Invar**
- **3M and ACCR**
- **CTC Corp and ACCC**

GAP Conductors

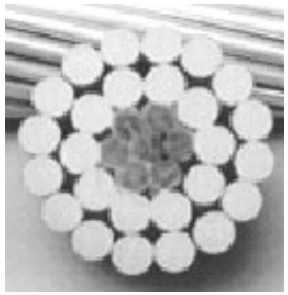


- **GTACSR** is a **G**ap Type **T**hermal Resistant **A**luminum Alloy A**CSR** conductor built with a heat resistant Al Zr aluminum alloy and a extra high strength galvanized steel core.
- **GZTACSR** is a **G**ap Type Super(**Z**) **T**hermal Resistant **A**luminum Alloy A**CSR** conductor built with a higher heat resistant Al Zr aluminum alloy and a extra high strength galvanized steel core.
- The gap is filled with a special "grease" material
- The conductors resemble an ACSR/SD type of conductor.
- Gap conductors are built to Japanese standards.

INVAR Conductors

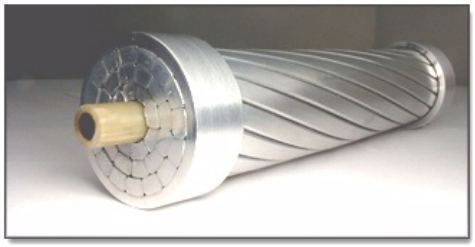
- **ZTACIR** is a Super(**Z**) **T**hermal Resistant **A**luminum Alloy **I**nvar steel ACS**R** conductor built with heat resistant Al Zr aluminum alloy and a galvanized Invar steel core.
- Aluminum Clad Invar steel is also used for higher temperature operation.
- The conductors resemble an ACSR type of conductor.
- "Invar" conductors are built to Japanese standards.

ACCR® Conductors



- ACCR® is an **A**luminum **C**onductors, **C**omposite Reinforced conductor built with a heat resistant Al Zr aluminum alloy and a proprietary fiber reinforced Aluminum Matrix Composite (AMC) core.
  * ACCR is a registered trade name of 3M Corp.
- ACCR® conductors are built basically to ASTM B232 (ACSR) or ASTM B779 (ACSR/TW) except utilize **ASTM B941** for the heat resistant Aluminum - Zirconium aluminum alloy strand wires, and **ASTM xxx** *(WK6283)* for the Aluminum Matrix Composite core .
- The designs are built to match the diameter of existing ACSR or ACSR/TW conductors.
- **code word name modified by /ACCR – eg "DRAKE/ACCR"**

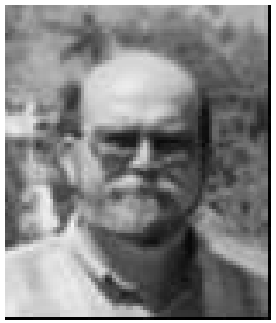
ACCC®/TW Conductors



- ACCC® is an **A**luminum **C**onductor **C**omposite **C**ore supported conductor built with annealed 1350 aluminum and a proprietary carbon / glass fiber composite strength member core.
  * ACCC is a registered trade name of CTC Corporation.
- conductors are built basically to ASTM B857 (ACSS/TW) except utilize the glass/carbon fiber composite core strength member.
- ACCC®/TW conductors are built with a solid strength member core and 1350 "O" temper TW aluminum strand wires (ASTM B609). The designs are built to match the diameter of existing ACSR conductors.
- **code word name modified by /ACCC - eg "DRAKE/ACCC/TW"**

Questions???

Thank you!



Gordon Baker received his Bachelor of Science with Honours in 1978 from Queens University in Kingston, Ontario, Canada. After graduating he joined BICC Phillips Cables in their Brockville, Ontario, Materials Engineering group. In 1985 he moved into the Applications Engineering Group responsible for the product design and application of Industrial and Utility type cable. In 1996 he transferred from Canada to the BICC Cables Engineering Group in West Nyack, New York where his primary product design and applications responsibility became Bare Overhead conductors. (The world wide BICC Cables Company was acquired by General Cable in 1999) Gordon is a member of a number of North American technical groups dealing with electrical conductors including the CSA Technical Committee for Overhead Conductors, Chairperson of the ASTM B01 Electrical Conductors Committee, and a member of the IEEE Towers, Poles and Conductors Committee.