Heavy Movable Structures, Inc.

SIXTH BIENNIAL SYMPOSIUM

October 30 - November 1, 1996

Doubletree Resort Surfside
Clearwater Beach, Florida

A Comparison of the 1988 AASHTO Electrical Requirements and the National Electrical Code

by

Rob Tannor, P.E., S.N. Tannor, Inc.

A COMPARISON OF THE 1988 AASHTO ELECTRICAL REQUIREMENTS AND THE NATIONAL ELECTRIC CODE

By Rob Tannor, P.E.

of

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6th Biannual Symposium
Heavy Movable Structures
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INTRODUCTION

The AASHTO Standard Specifications for Movable Highway Bridges has only been revised five times including its first printing in 1938. Many of the electrical requirements are antiquated and don't keep up with the rapid changes in electronics, electrical materials, and advances in manufactured electrical products.

There is a substantial installation cost difference between both "Codes".

The National Electric Code is changed every three years. The actual electrical code changes are suggested by the public at large and are acted upon by specific code making panels. There is even a process by which code changes can be appealed. The latest National Electric Code adopted by most municipalities is the 1996 edition.

The AASHTO specification is a guide to Consulting Engineer's to use as reference when doing design and the National Electric Code is the minimum standard used by electrical inspectors when determining if an electrical installation is safe.

AASHTO versus NEC

Paragraph 2.10.10 Electric is the beginning of the AASHTO Electrical Specifications

Paragraph 2.10.11 states: "The electrical equipment shall conform to the Standardization Rules of the IEEE and of NEMA. The latest editions of the National Electrical Safety Code and the National Electrical Code and local ordinances shall apply to the electrical material, construction, and installation, except as provided otherwise herein."

ENGINE GENERATOR AND TRANSFER SWITCH

Paragraph 2.10.23 and 2.10.24 are titled Engine Generators and Automatic Transfer Switches. Both are used as in providing an emergency source of power to operate the bridge.

The AASHTO specification gives criteria for Automatic Transfer Switch operation but no critical rating guidelines.

NEC Article 700-Emergency Systems goes to a much greater length.

Article 700-5a states: An emergency system shall have adequate capacity and rating for all loads to be operated simultaneously.

Article 700-5b says: The alternate power source shall be permitted to supply emergency, legally required standby, and optional standby system loads where

automatic selective load pick-up and load shedding is provided as needed to ensure adequate power to (1) the emergency circuits; (2) the legally required standby circuits; and (3) the optional standby circuits, in that order of priority. The alternate power source shall be permitted to be used for peak load shaving, provided the above conditions are met.

Peak load shaving operation shall be permitted when satisfying the test requirements of Section700-4(b) [which calls for periodic system tests]. Article 700-8 of the NEC requires a sign to be placed at the service entrance indicating type and location of on-site emergency power sources. Article 700-9 requires all boxes and enclosures for emergency circuits be permanently marked so as to be readily identified as components of the emergency system.

Also all wiring from the emergency source to the emergency source distribution system are to be kept entirely independent from all other wiring, equipment, and should not enter raceways, cable boxes, or cabinets with other wiring.

BRAKES AND LIMIT SWITCHES

AASHTO Paragraph 2.10.25 Electrically operated motor brakes says in part: "When so specified brakes shall be provided with heating elements to prevent the accumulation of moisture and frost, and for the addition of limit switches for control, and lights to indicate the position of the brakes and their hand release levers.

Usually the brakes have a brake set limit switch, a brake released limit switch, and a hand release limit switch. The terminals for a commonly used Cutler Hammer E50 series Limit Switch are suited for #22 AWG wire to #12 AWG wire.

SWITCHES [Disconnect]

AASHTO Paragraph 2.10.35 says: An enclosed switch or circuit breaker shall be provided as a disconnect for the supply feeder, with a pole for each ungrounded conductor. A similar switch, or circuit breaker capable of being operated as a switch, shall be provided as a disconnect for each motor, light, signal, or other circuit.

The NEC in Article 430-Motors, Motor Circuits and Controllers addresses motor disconnecting means.

Some important requirements not mentioned in AASHTO are:
Article 430-102a Disconnecting means to be in-sight from the motor controller and disconnect the controller.

Article 430-102b Disconnecting means to be located insight from the motor location and driven machinery location.

Article 430-109 Disconnecting means are to be motor-circuit switch rated in HP, a circuit breaker, or molded case switch, and shall be a listed device.

Article 430-110 Disconnecting means rated 600V or less shall have ampere rating of 115% of motor full load current.

CONTROL DESK [AND OTHER PANELS]

Paragraph 2.10.46 Control Console says: The span shall be operated from a control console on which there shall be located the switches for the span operating motors; seating switches; by pass switches; instruments; position indicators or meters; indicating lights; and all other control devices and apparatus necessary or pertinent to the proper operation and control of the span and its auxiliaries.

...Where specified by the Engineer, the top of the console may be of No. 10 U.S. Standard guage stainless steel with a non-reflecting finish. The horizontal and sloping sections of the top shall be accurately cut to insure a close fit...The console frame shall be constructed of sheet steel of not less than No. 11 U.S. Standard guage...All outgoing control connections from the console shall be brought to suitably marked barrier-type terminal boards supported on straps securely attached to the console frame.

The NEC Article 373 for Cabinets, Cutout boxes and meter socket enclosures under 373-10(b) states: The design and construction of cabinets and cutout boxes shall be as to secure ample strength and rigidity. If constructed of sheet steel, the metal thickness shall not be less than .053 in (1.53mm) [17 guage] uncoated.

Article 384-30 of the NEC title Panels gives no material specifications: "The panels of switchboards shall be made of moisture resistant, non combustible material."

Many panelboard and control console manufacturers do not make 10 gauge or 11 gauge consoles as standard products. See Attachment 1.

TERMINAL STRIPS IN CONTROL PANELS

AASHTO Paragraph 2.10.47 states: Control panels shall be either back wired or front wired. All interconnections shall be made by either copper bus bars or insulated cables of equivalent current carrying capacity. All wiring at board shall

terminate in terminal strips supported in a substantial manner and all conductor shall be copper with insulation approved for control panels.

NEC has no requirement for wiring at boards to terminate in terminal strips.

WIRE

Paragraph 2.10.48 Electric Wire and Cables declares: "In general, unless otherwise specified, all wires external to the control console and control panels shall be suitable insulated and jacketed, and shall be drawn into metal conduits. The insulation shall be of not lesser quality than Synthetic Rubber, Moisture-Resisting 60C, or types THW, THWN, XHHW.

Also AASHTO suggests "Unless otherwise specified no wires smaller than No. 10 AWG guage shall be used except that No. 12 guage will be permitted for fixture drop for service lights, and No. 14 guage for control console and control panel wiring."

The NEC Article 310 gives us the requirements for conductors for General wiring and Table 310-13 gives conductor applications and insulation. The NEC on Tables B310 shows the Ampacities of conductors.

THWN [PVC with a Nylon Jacket] is long lasting and provides for a less costly installation over equivalent sized XHHW or USE-RHH-RHW insulation [Cross-Linked Polyethylene]. The increased thickness of XHHW or RHW insulation will require bigger conduits. See Attachment 3.

WIRE TERMINALS

Paragraph 2.10.48 of AASHTO describes terminals for wires: "The ends of all wires, No. 8 AWG guage and smaller, shall have solderless high compression indent type terminals where they terminate at control panels, control consoles, terminal strips, lighting panels, junction boxes, and similar points. Similar connections for larger wires shall terminate in pressure lugs or screw-type solderless connectors.

The NEC states the requirements for electrical connectors simply in Article 110-14a "Terminals": "Connection of conductors to terminal parts shall ensure a thoroughly good connection without damaging the conductors and shall be made by means of pressure connectors (including set screw type), solder lugs or splices to flexible leads.

The AASHTO specification has not been updated to include advances in electrical terminals that do not require any screws but use an electrical spring cage clamp to properly torque an electrical connection without having to worry about

vibration loosening the connections. See the WAGO advertisement in Attachment 2.

TAGGING OF WIRES

Paragraph 2.10.49 of AASHTO dictates: "Wires shall be identified and the designation permanently marked on durable fiber tags, or on metal or plastic bands with heat-shrink protective sleeving so that any wire may be traced from terminal to terminal, or as specified. The designations used shall correspond with those shown on wiring diagrams.

Wire tagging is not generally required by the NEC, but for color coding according to ground or neutral colors, voltage colors, and special situations.

The AASHTO tagging specification can be embellished to allow the specific use of computer laser printer tags and dot matrix printer tags. Also, there are wire tag manufacturers that make tag machines that produce wrap around tags at the job site.

WIRE FILL

The AASHTO Specifications in Paragraph 2.10.51 Raceways, Metal conduits, Conduit fittings, and Boxes is perhaps the most wasteful and costly of requirements in the electrical specifications.

A) AASHTO Paragraph 2.10.51 says that circuits for more than three motors shall not be in one conduit.

The NEC has restrictions on wire fill, none are as restrictive as AASHTO. Article 346-5 "Number of Conductors in Conduit" says: The number of conductors permitted in a single conduit shall not exceed the percentage fill in Table 1, Chapter 9." This table limits conduit fill to 40% of inside area of conduit for over two conductors.

Article 352-4 "Number of Conductors in Raceways" says: "The number of conductors installed in any raceway shall not be greater than the number for which the raceway is designed."

B) AASHTO Paragraph 2.10.51 goes on to require: "All boxes, including conduit outlet boxes, and other fittings shall be cast iron, malleable iron, cast aluminum or sheet aluminum of sufficient thickness to permit the conduit to be threaded into the fitting, All boxes and other fitting must be weatherproof throughout, in particular at conduit connections and be free from rough edges and rough surfaces. Large boxes, for which cast iron or malleable iron is not practical, may be built of steel plates and angles not less than 3/16-inch (4.8mm) thick, with all

joints continuously welded. Cast iron, malleable iron or welded conduit outlet boxes, other boxes and fittings shall be galvanized. All boxes shall be provided with drain holes.

The NEC has no such requirement. Overuse of cast iron boxes is overly expensive and delays in cast iron box procurement have slowed job production. There are other suitable choices such as standard product Nema 4X Stainless Steel enclosures.

C) AASHTO Paragraph 2.10.51 goes onto limit the number of 90 degree bends in a conduit run: "Bends in conduits shall be used sparingly. The total angle of all bends between junction boxes shall preferably not exceed 180 degrees.

The NEC Article 366-11 "Number in one run" states: "There shall not be more than the equivalent of four quarter bends (360 degrees total) between pull points, e.g., conduit bodies boxes."

D) AASHTO Paragraph 2.10.51 suggests that conduit supports be on not more than 6-ft (1.829m) centers.

NEC Article 365-112 "Supports" says: "Rigid metal conduit shall be installed as a complete system as provided in Article 300 and shall be securely fastened in place. Conduit shall be supported at least every 10 ft (3.05m)."

There are exceptions that allow even greater support distances.

GROUNDING & LIGHTNING PROTECTION

AASHTO Paragraph 2.10.57 says that Grounding and Lightning Protection Systems shall be provided to meet or exceed the requirements of the NEC.

With increasing number of electronic components on movable structures both lightning protection systems and grounding requirements must be incorporated into electrical control system design.

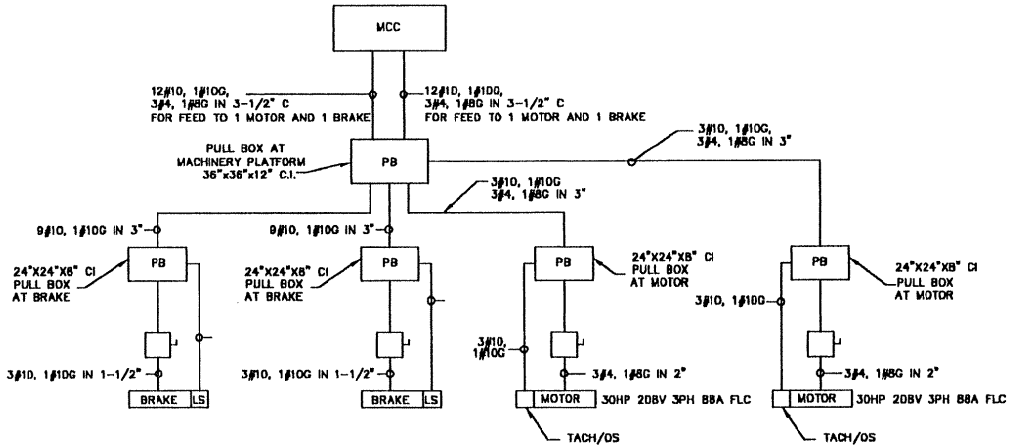
COST COMPARISON BASIS

AASHTO REQUIREMENT	NEC REQUIREMENT - CODE COMPLIANT
PVC Coated conduit	PVC Coated Conduit *
Cast Iron Boxes	Nema 4X Stainless Steel boxes *
Maximum of 2 90 degree bends	Maximum of 4 90 degree bends
Rigid conduit supports every 6 feet	Rigid conduit supports every 10 feet
Max three AC Motor feeds per conduit	40% of conduit cross sectional area
Assume wire to be USE-RHH-RHW	Assume THWN
Minimum #10 Wire for control circuits	#14 Wire rated for 15 amp control circuit
Buchanan style terminal block with indent type wire termination	Cage clamp wire terminal using no wire termination

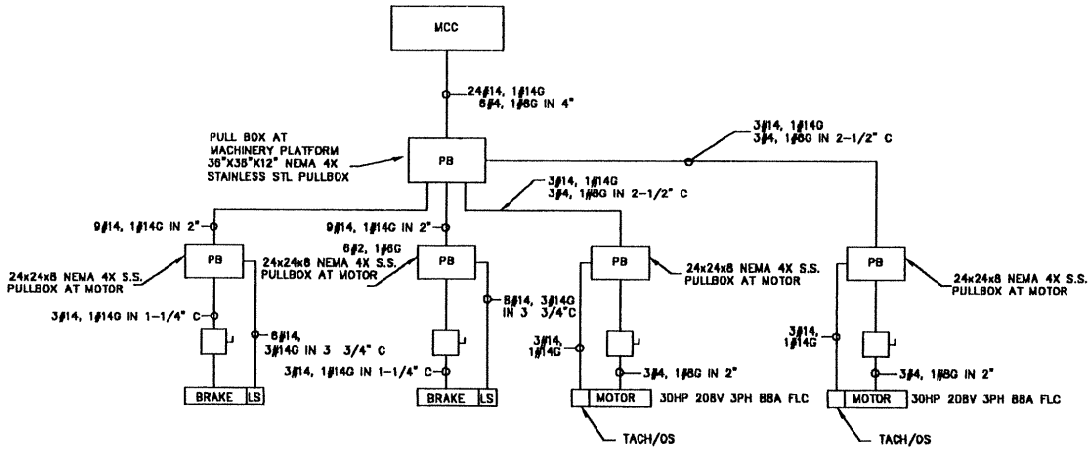
* PVC Schedule 80 conduit would be a suitable corrosion resistant choice, more cost savings would apply.

* If PVC conduit is used, change boxes to Fiberglass Reinforced Polyester (FRP) boxes.

1988 AASHTO ELECTRICAL REQUIREMENTS



NATIONAL ELECTRIC CODE



S.N. TANNOR, INC.

HEAVY MOVABLE STRUCTURES
6th BIANNUAL SYMPOSIUM

TITLE
1988 AASHTO ELECTRICAL REQUIREMENTS
VS.
NATIONAL ELECTRIC CODE

DWG. NO.	SCALE	DATE	SHEET
1	NONE	8/2/96	1

D C B A

8 7 6 5 4 3 2 1

PROJECT | ESTIMATE NO.

ESTIMATE ITEM NEC COST | SHEET OF

EST. BY | CHECKED BY | DATE

	DESCRIPTION	QUANTITY	MATERIAL UNIT	MATERIAL PER	MATERIAL EXTENSION	MANHOURS UNIT	MANHOURS PER	MANHOURS EXTENSION
	MCC TO 36x36x12 PB							
100' RUN	4" GRC 1 Run at 100'	100 LF	960	C	960	45	C	45
	4" GRC 90s	4	65	E	260	4.50	E	18
	INTERMEDIATE NEMA 4X Box	1	1025	E	1025	12	E	12
	CONDUIT SUPPORTS 10' OC	10	50	E	5	25	E	3
	36x36x12 NEMA 4X BOX	1	1025	E	1025	12	E	12
	36x36x12 4X SS TO 24x24x8 TO MOTORS							
30' RUN	2½" GRC 2 RUNS x 30'	60 LF	520	C	312	22.50	C	14
	2½" 90s 4 x 2 Runs	8	25	E	200	2.25	E	18
	INTERMEDIATE PB 2 RUNS	2	555	E	1110	6	E	12
	CONDUIT SUPPORTS 10'/OC	6	50	E	3	2.25	E	2
	24x24x8 Nema 4x JB	2	555	E	1110	6	E	12
30' RUN	2" GRC 2 RUNS x 30'	60 LF	520	C	312	16.50	C	10
	2" 90s 4 x 2 Runs	8	14	E	28	1.50	E	12
	INTERMEDIATE PB 2 RUNS	2	555	E	1110	6	E	12
	CONDUIT SUPPORTS 10'/O.C.	6	50	E	3	2.25	E	2
	24x24x8 Nema 4x JB	2	555	E	1110	6	E	12
5' RUN	BRAKES PULLBOX TO BRAKES + BRAKE LIMITS							
	1¼" LIQUIDTITE NON METL	90 LF	656	C	262	1.5	C	3
5' RUN	MOTOR PB TO MOTORS							
	1¼" LIQTITE FLEX	10	656	C	66	1.5	C	2
	2" LIQTITE FLEX	10	856	C	86	3.0	C	3
	WIRE							
	#8 WIRE THWN	195	250	M	49	1.5	M	3
	#4 WIRE THWN	880	630	M	554	2.1	M	18
	#14 WIRE THWN	3760	68	M	256	7.50	M	28

PRICING SHEET | TOTAL | 9846 | 296

PROJECT | ESTIMATE NO.

ESTIMATE ITEM AASHTO COST | SHEET OF

EST. BY | CHECKED BY | DATE

AASHTO

DESCRIPTION	QUANTITY	MATERIAL UNIT	PER	MATERIAL EXTENSION	MANHOURS UNIT	PER	MANHOURS EXTENSION
MCC TO 36 x 36 x 12 PB							
3½" GRC 2 Runs x 100'	200 LF	812	C	1624	37 50	C	75
3½" GRC 90s 4 x 2 Runs	8	57	E	456	3 75	E	30
{INTERMEDIATE PULLBOX}	1	4048	E	4048	8	E	8
{(NO MORE THAN 2 90s)}							
CONDUIT SUPPORTS 6' O.C.	33	1	E	33	25	E	8
36 x 36 x 12 CAST IRON BOX	1	4048	E	4048	64	E	64
36 x 36 x 12 CI JB TO 24x24x8							
3" GRC = 30' x 4 RUNS	120	667	C	800	30	C	36
3" GRC 90s = 4 x 4 RUNS	16	36 50	E	584	3	E	48
{INTERMEDIATE PULLBOX}	4	1895	E	7580	8	E	32
{NO MORE THAN 2 90s.}							
CONDUIT SUPPORTS 6' O.C.	20	1	E	20	25	E	5
24x24x8 CAST IRON BOX	4	1895	E	7580	18	E	72
BRAKES PULLBOX TO BRAKES + BR LIMITS							
1½" LIQUIDTITE NONMETAL FLEX	40 LF	687	C	275	22 50	C	9
4 x 5' x 2 BRAKES	—	—			—		
MOTOR PULLBOX TO MOTORS							
1½" LIQ TITE NM FLEX	10 LF	687	C	69	22 50	C	2
2" LIQ TITE NM FLEX	10 LF	856	C	86	30	C	3
WIRE							
#8 XLP USE	305	358	M	109	16 50	M	5
#4 XLP USE	880	676	M	595	22 50	M	20
#10 XLP USE	3760	252	M	948	12 70	M	48
TOTAL				28855			465

PRICING SHEET

QUOTATION

GRAYBAR ELECTRIC CO. INC.

21-15 BRIDGE PLAZA NORTH
LONG ISLAND CITY, NY 11101
TEL: (718) 392-2000 FAX (718) 361-1942

August 02 1996

JOB NAME/AGENCY: S N TANNOR JOB

NAME: S N TANNOR

ATT ROB TANNOR

SALESMAN: GERRY GILLIGAN -1263

FOLDER # 358

THE FOLLOWING REFERENCE NUMBER MUST APPEAR ON ALL FUTURE CORRESPONDENCE: **10354**

ITEM	QUANTITY	PREFIX	CATALOG #//DESCRIPTION	PRICE	UNIT	EXT.
1	1	HOF	D3L36H3612SSLP	$1,024.58	E	$1,024.58
2	1	OZG	YW363612	$4,047.63	E	$4,047.63
3	2	HOF	D3L24H2408SSLP	$554.52	E	$1,109.04
4	2	OZG	YW242408	$1,894.56	E	$3,789.12
			ITEM 1 & 3 7-10 DAYS			
			LEAD TIME			
			ITEMS 2 & 4 3-5 DAYS			
			LEAD TIME			

COMMENTS:

OZG FREIGHT ALLOWED

HOFFMAN FREIGHT ALLOWED ON 3,000.00 ORDER ONLY

TOTAL : $9,970.37

GRAYBAR QUOTE DEPT.

CARL KLEIN

PRICES ARE F.O.B. SHIPPING POINT, UNLESS OTHERWISE NOTED. QUOTATION SUBJECT TO GRAYBAR ELECTRIC CO. INC. STANDARD TERMS AND CONDITIONS OF SALE. COPY AVAILABLE UPON REQUEST.

AASHTO COST VS NEC COST SUMMARY

AASHTO Summary

Total Materials			28,855.00
Total Labor Manhours		465.00	
US Average Labor Cost of $45 per hour	X	45.00	
		20,925.00	20,925.00
Total Cost			**49,780.00**

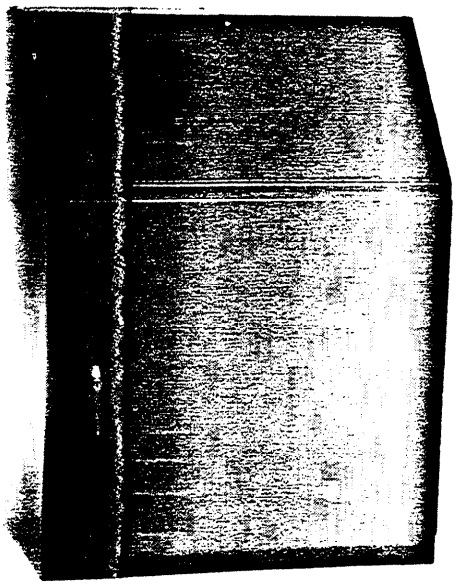
NEC Summary

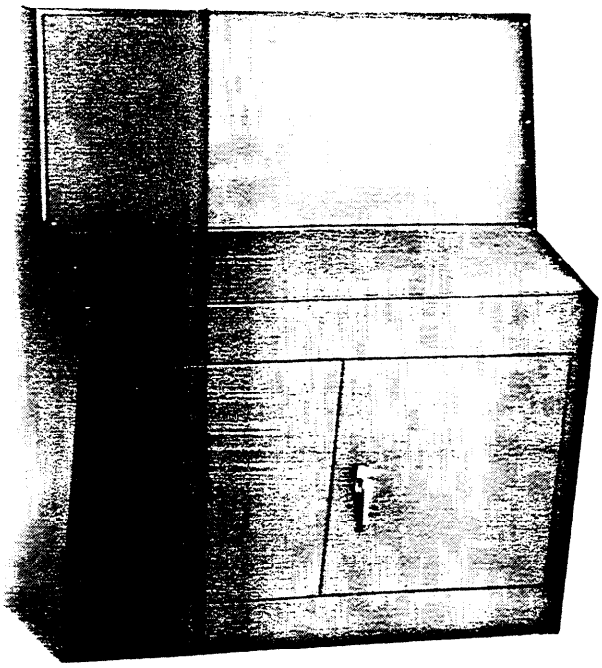
Total Materials			9,846.00
Total Labor Manhours		256.00	
US Average Labor Cost of $45 per hour	X	45.00	
		11,520.00	11,520.00
Total Cost			**21,366.00**

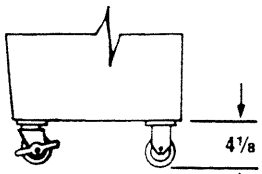
CONCLUSION

The National Electric Code gives the Design Engineer more detailed requirements for electrical design of a movable bridge than the AASHTO specification. The NEC is updated every three years with input of the public at large while the AASHTO specifications are not updated regularly.

The AASHTO specification adds cost to the installation over the National Electric Code.







(OPTIONAL) CASTER KIT

NOTE:
Writing desks must be ordered separately. Sub panels are furnished with W1C, W2C, and W2B Consoles.

TECHNICAL DATA

APPLICATION—

- Wiegmann W1 and W2 Consoles are heavy duty, oil and dust tight enclosures designed to hold electrical and electronic controls. Pushbuttons, pilot lights, meters, switches can be mounted on sloping control surfaces. Interior components can be mounted on standard back panel.

CONSTRUCTION—

- Fabricated from 14 gauge steel.
- Seams are continuously welded and ground smooth.
- A 3PT keylocking handle is provided on front main door.
- The main door on the W1 series console is raised.
- The main door on the W2 series console is flush.
- Control panels are hinged along bottom edge.
- Control panels, access panels and instrument panels have captivated screws which thread into sealed wells.
- Door stops are provided to hold control panel open.
- A removable print pocket is provided.
- Standard closed cell neoprene gasket is provided.
- Top and body on W2C's are combined in one unit with no barrier permitting easy wiring.
- The top must be ordered separately for W2B's.
- With standard removable sub panel.

TOPS FOR W2B's—

- Fabricated from 14 gauge steel.
- Seams are continuously welded and ground smooth.
- Instrument and access panels have captivated screws which thread into sealed wells.
- Standard closed cell neoprene gasket.

WRITING DESK—

- Fabricated from 14 gauge steel.
- Seams are continuously welded and ground smooth.
- Desks are removable and attach easily to console front.

FINISH—

- White inside and gray primer outside over phosphatized surfaces. Tops are gray primer inside and out. Instrument panels and access panels are white enamel inside and gray primer outside. Desks are gray primer. Sub Panels are white enamel.

OPTIONAL SPECIALTIES—

- E. M. Wiegmann will gladly punch special holes, provide hubs, provide special finishes, provide special material or even manufacture the enclosure to your special requested size.

INDUSTRY LISTING—

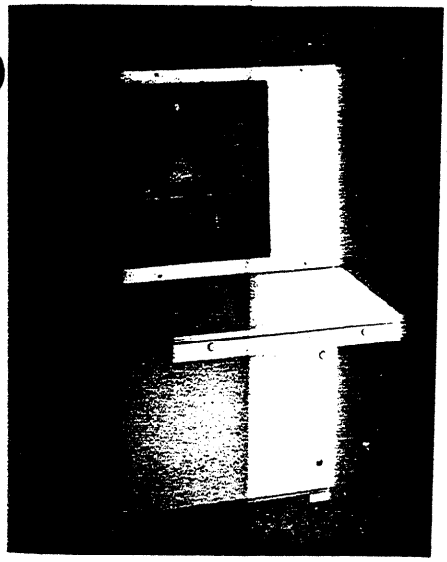
- Meets NEMA Type 12 and Type 13 requirements.
- Listed by Underwriters Laboratories, Inc.
- CSA Certified.

ACCESSORIES—

- See pages 213-226.

E. M. WIEGMANN & COMPANY, INC.
501 DOUGLAS ROAD • FREEBURG, ILLINOIS 62243 • 618/539-3193 • FAX 618/539-5794

ATTACHMENT 1



Application

Designed to house and protect electrical and electronic controls and instruments in indoor environments where dust, dirt, oil, and water may be encountered. Individual console units can be assembled in many configurations. Top and base are extra deep so rack-mounted equipment and other controls which require additional clearance can be easily installed inside. Instrument covers and doors have large clear areas for pushbuttons, pilot lights, meters, switches, instruments, and CRT's. Smooth, blended surfaces and attractive finish complement other electronic equipment.

Construction

- 14 gauge steel
- Seams continuously welded and ground smooth
- Easily removable and interchangeable doors and instrument covers are held closed by nearly flush oil-tight latches
- Hidden hinges, with removable hinge pins, permit 120° opening
- Horizontal channels welded inside top and base units support optional panels, swing-out panels, and rack mounting angles

Top Unit

- Open bottom permits connection to other console units or to inside bottom cover
- Rigid instrument door attached with hinges along bottom edge and latched by fasteners along top of unit
- Stops hold instrument door open
- Grounding stud provided in unit

Consolet Unit

- Open top and bottom permits connection to other console units or covers
- Rigid instrument door attached with hinges along top edge and latched by fasteners along front of unit
- Stops hold instrument door open
- Unit can be inverted for use as a writing desk
- Grounding stud provided in unit

Consolet Top Unit

- Open bottom permits connection to other console units or can be closed off with an inside bottom cover
- Rigid instrument door attached with hinges along the back edge and latched by fasteners along front of unit
- Stops hold instrument door open
- Grounding stud provided in unit

Dual-Access Top Unit

- 30.00 x 21.50-inch deep top unit provides extra capacity for large CRT's and operator interface equipment
- Accessible front and rear facilitates equipment installation and service
- Mounting channels front to back and left to right both top and bottom, enable the full line of rack mounting accessories as well as panels to be installed inside
- **Order separately: Your choice of any two external instrument covers or doors:**

  1. Instrument door with hinges at bottom and quarter-turn latches at top; two stop arms included
  2. Instrument cover with recessed captive screw fasteners top and bottom
  3. Full-view window door with hinges at bottom and quarter-turn latches at top; two stop arms included. Window is 1/4" thick acrylic surrounded by aluminum frame finished in textured matte black.
  4. Operator interface cover secured with recessed captive screw fasteners top and bottom. Interface cover is designed to be used in conjunction with an Operator Interface Bezel. Bezel can be ordered pre-fabricated to fit your brand of operator interface or industrial workstation. See page 248 for additional information regarding the selection of an operator interface bezel.

- **The four external instrument doors and covers are designed to fit either the front or the rear of the new dual-access top unit**
- Grounding stud provided in unit

Base Unit

- Open top and bottom permits connection to other console units or to dual-purpose cover or inside bottom cover
- 24.00-inch (610mm) and 36.00-inch (914mm) wide units have single door hinged on left and latched on right (units can be inverted for door to hinge on right); 48.00-inch (1219mm) and 60.00-inch (1524mm) wide units have overlapping double doors and 3-point latch
- Data pocket is high-impact thermoplastic
- Grounding stud provided in unit

Dual-Access Base

- Open top and bottom permits connection to other console units or to dual-purpose cover or inside bottom cover
- Doors on front and back provide easy access to equipment mounted inside
- 24.00-inch (610mm) and 36.00-inch (914mm) wide units have single door hinged on left and latched on right (units can be inverted for door to hinge on right); 48.00-inch (1219mm) and 60.00-inch (1524mm) wide units have overlapping double doors and 3-point latch
- Data pocket is high-impact thermoplastic
- Grounding stud provided in unit

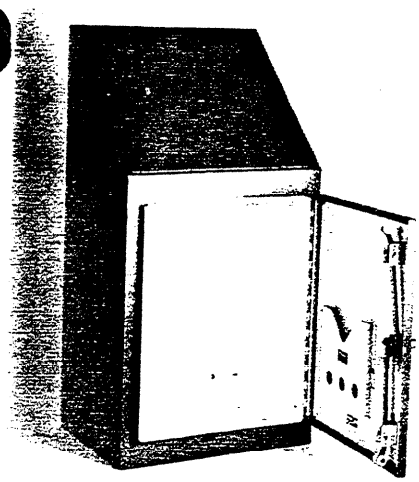
Dual-Purpose Cover

- Fits top opening of consolet or base unit to provide a closure
- Fits bottom opening of top, consolet, consolet top, or base unit to provide a closure
- Used as a base on top, consolet, or base unit

Inside Bottom Cover

- Fits inside bottom opening of top, consolet, or bottom unit to provide a closure
- Used as a barrier between units
- Hardware furnished

Phone: 612-421-2240
Fax: 612-421-1556



Application

Designed to house electrical and electronic controls, instruments, and components. Heavy-duty construction provides protection from dust, dirt, oil, and water. Pushbuttons, pilot lights, meters, switches, etc. can be mounted on the sloping control panel. Interior components can be mounted on stationary panels located on sides and back of enclosure.

Construction

- 14 gauge steel
- Seams continuously welded and ground smooth, no holes or knockouts
- 3-point latch on front access door operated by oil-tight key locking handle
- Control panel attached with continuous hinge along bottom edge
- Captivated panel screws thread into sealed wells
- Stops hold control panel open at 90°
- Data pocket is high-impact thermoplastic
- Oil-resistant gasket and adhesive
- Collar studs provided for mounting one, two, or three optional panels

Finish

White enamel inside with recoatable ANSI 61 gray outside finish over phosphatized surfaces. Optional panels are white enamel.

Industry Standards

NEMA Type 12
UL 508 (See table)
IEC 529, IP65

Accessories

Air conditioners and heat exchangers for this enclosure can be found in Hoffman's Specifier's Guide for Climate Control Products.

Need More Information?

Modifying Your Enclosure?

We can modify or customize this enclosure to your specs. See page 502 for more information.

Standard Sizes

Series 9 Consoles

Console Catalog Number	Width B	*Panel Catalog Number	*Casters Catalog Number
■ C-924B	24.00 (610)	A-30P20	C-10C
C-936B	36.00 (914)	A-30P20/A-30P30	C-10C

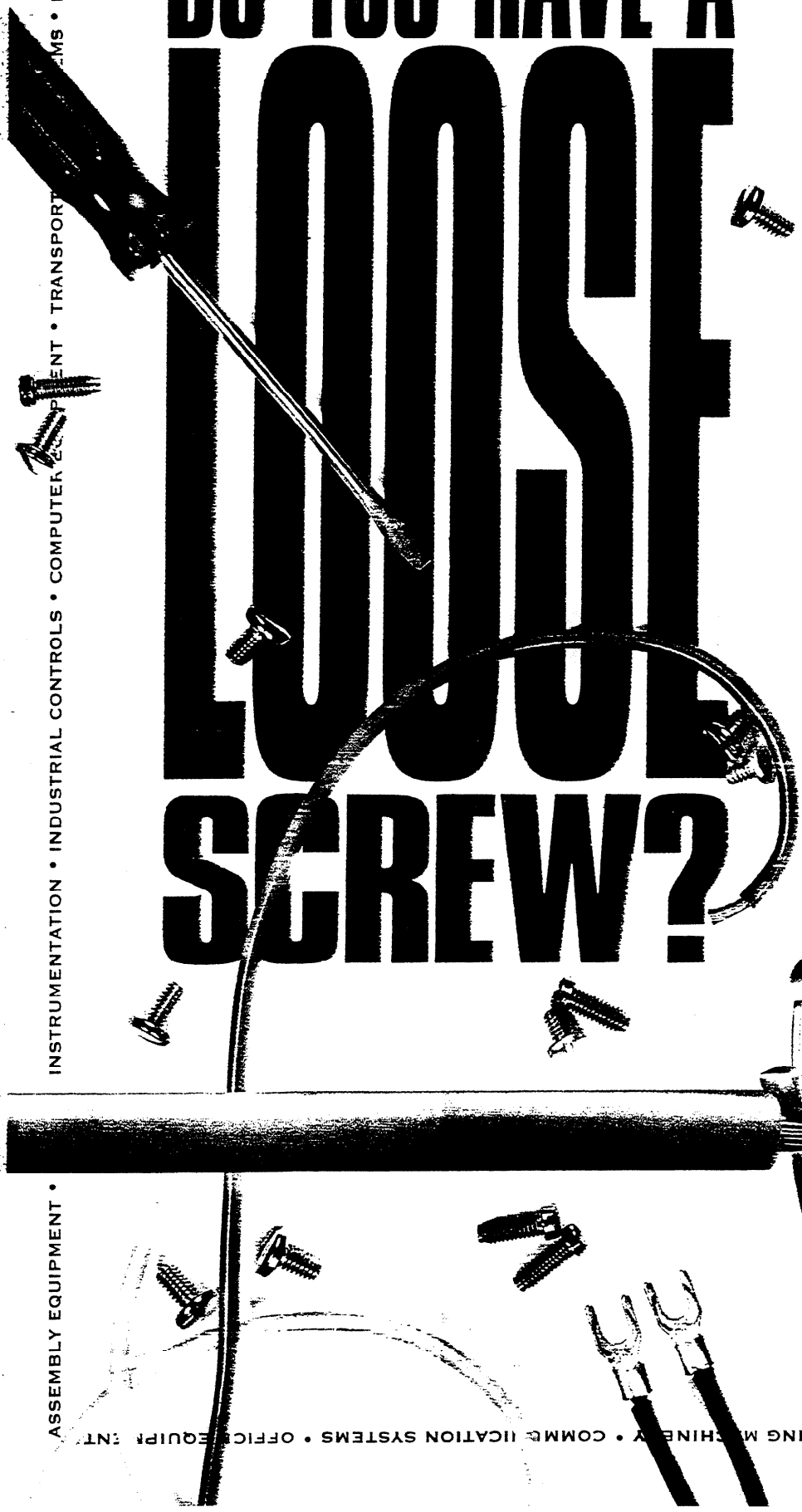
Millimeter dimensions ( ) are for reference only; do not convert metric dimensions to inch.
■ UL 508
* Panels and casters must be ordered separately.
See following pages for additional details and panel sizes.

Hoffman
A Pentair Company
Phone: 612-421-2240
Fax: 612-421-1556

•MOTOR CONTROLS • PRODUCTION/TEST EQUIPMENT • POWER GENERATION SYSTEMS • MACHINE CONTROLS •

ATTACHMENT 2

DO YOU HAVE A LOOSE SCREW?



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ATTACHMENT 3

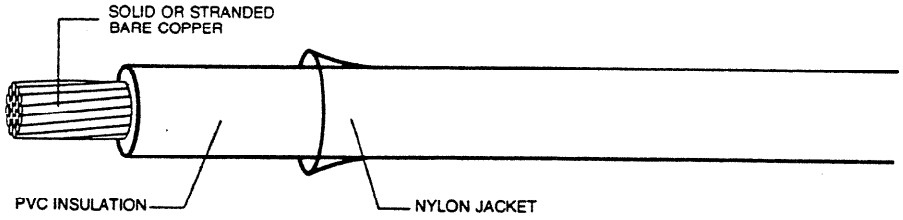
Type THHN-THWN

PVC Insulation with Nylon Jacket

UL File Numbers: THHN-THWN - E18964 & E18420 MTW - E51461 & E51303

14 AWG - 750 MCM • 600V • GASOLINE AND OIL RESISTANT • VW-1

ENGINEERING
DATA SHEET
Type THHN-THWN
600V • 90°C
DATE: JANUARY 1987



SCOPE

This specification covers single conductor cables having polyvinyl chloride (PVC) insulation with an overall nylon jacket.

Cables conform to the following standards:
UL-83 for Thermoplastic Insulated Wire
UL-758 for Appliance Wiring Material
UL-1063 for Machine Tool Wire
(stranded conductors only)
Federal Specifications J-C-30A

APPLICATIONS

UL listed and OSHA acceptable. (Consult factory for CSA THHN approval). Type THHN-THWN may be used for power and control circuits, for installation in conduit, duct or other recognized raceways, in wet or dry locations and in the presence of oil, gases, gasoline and chemicals, in accordance with the National Electrical Code (and subject to local code requirements). Note: may also be used for wiring of machine tools (stranded conductors only) and appliances.

CONSTRUCTION

Conductors
Bare, soft annealed copper per ASTM B-3
Sizes 14 – 10AWG
Solid or unilay concentric stranded (class C)
ASTM B-3 or ASTM B-8 and UL-83
Sizes 8 – 2AWG
Concentric stranded (class C)
ASTM B-8, UL-83 and UL-1063
Sizes 1AWG - 1000MCM
Concentric, compressed stranded (class B)
ASTM B-8, UL-83 and UL-1063

Insulation
High dielectric polyvinyl chloride (PVC)
UL-83 and UL-1063

Overall Jacket
Nylon
UL-83 and UL-1063

Cable Identification
Ink print on jacket
Sizes 14 – 10AWG (solid conductors)
"(size) AWG Type THHN or THWN Gasoline and Oil Resistant II 600V A.I.W. Corp. (UL) AWM VW-1"
Sizes 14AWG – 1000MCM (stranded)
"(size) AWG (or MCM) Type MTW or THHN or THWN or Gasoline and Oil Resistant II or AWM 600V A.I.W. Corp. (UL) VW-1"

Maximum Conductor Temperature and Voltage Rating:

Type	Oil	Wet	Dry	Voltage
THHN-THWN	75°C	75°C	90°C	600V
MTW	60°C	60°C	90°C	600V
AWM 1316 to 1321	80°C	—	105°C	600V
AWM 1408 to 1414	60°C	60°C	90°C	600V
*AWM 1452 to 1453	80°C	—	90°C	1000V

*14-10AWG only

CABLE DATA
ES-02682

SIZE (AWM OR MCM)	STRANDS NO./O.D. (INCHES)	PVC INSUL. THICK. (INCHES)	NYLON JACKET THICK. (INCHES)	APPROX. OUTSIDE DIAMETER (INCHES)	AMPACITY THWN[1] 75°C	AMPACITY THHN[1] 90°C	AMPACITY MTW[2] 90°C	APPROX. WEIGHT 1000 FT. (POUNDS)	STANDARD PUT-UP[3]	STOCK COLORS[4]
14	Solid	.015	.004	.105	15	15	—	16	S500/R2500	0-10
12	Solid	.015	.004	.125	20	20	—	24	S500/R2500	0-10
10	Solid	.020	.004	.155	30	30	—	38	S500/R2500	0-10
14	19/.0147	.015	.004	.115	15	15	15	17	S500/R2500	0-10
12	19/.0185	.015	.004	.135	20	20	20	26	S500/R2500	0-10
10	19/.0234	.020	.004	.170	30	30	30	40	S500/R2500	0-10
8	19/.0295	.030	.005	.220	50	55	40	66	S500/R1000	0-5, 8, 9
6	19/.0372	.030	.005	.260	65	75	55	100	R500/R1000	0-5, 8, 9
4	19/.0469	.040	.006	.335	85	95	70	159	R500/R1000	0-5, 8, 9
3	19/.0526	.040	.006	.360	100	110	80	191	R500/R1000	0-5, 8, 9
2	19/.0592	.040	.006	.395	115	130	95	241	R500/R1000	0-5, 8, 9
1	19/.0664	.050	.007	.450	130	150	110	305	R500/R1000	0-5, 8, 9
1/0	19/.0745	.050	.007	.490	150	170	125	377	R500/R1000	0
2/0	19/.0837	.050	.007	.535	175	195	145	468	R500/R1000	0
3/0	19/.0940	.050	.007	.585	200	225	165	581	R500/R1000	0
4/0	19/.1055	.050	.007	.640	230	260	195	722	R500/R1000	0
250	37/.0822	.060	.008	.710	255	290	215	860	R500/R1000	0
300	37/.0900	.060	.008	.760	285	320	240	1018	R500/R1000	0
350	37/.0973	.060	.008	.810	310	350	260	1180	R500/R1000	0
400	37/.1040	.060	.008	.855	335	380	280	1342	R500/R1000	0
500	37/.1162	.060	.008	.940	380	430	320	1661	R500/R1000	0
600	61/.0992	.070	.009	1.040	420	475	355	2007	R500/R1000	0
750	61/.1109	.070	.009	1.140	475	535	400	2497	R500/R1000	0

[1]Allowable ampacity of not more than three conductors in raceway or cable or earth (directly buried), based on ambient temperature of 30°C (86°F), per Table 310-16 of the 1987 National Electrical Code (NFPA 70-1987).

[2]Allowable ampacity of Type MTW conductors in cable or raceway per Table 11-1(b) of the Standard for Electrical Metalworking Machine Tools and Plastic Machinery (NFPA 79-1985).

[3]**Standard Put-Ups:**
R — Reels, S — Spools

[4]**Colors:**
0 — Black
1 — White
2 — Red
3 — Green
4 — Orange
5 — Blue
6 — Purple
7 — Grey
8 — Yellow
9 — Brown
10 — Pink

Nonstock colors available upon request. Consult factory.

The data listed above is approximate and subject to normal manufacturing tolerances. Specifications are subject to change without notice.

AMERICAN INSULATED WIRE CORPORATION
36 Freeman St., P. O. Box 880, Pawtucket, RI 02862 • 401-726-0700

ATTACHMENT 3

ENGINEERING
DATA SHEET
Type USE-RHH-RHW
600V • 90°C
DATE: JANUARY 1987

Type USE-RHH-RHW

Cross-Linked Polyethylene (XLP) Insulation

UL File Numbers: USE - E24499 RHH-RHW - E18321

14 AWG‡ - 1000 MCM • 600V • 75°C WET AND 90°C DRY

SCOPE

This specification covers single conductor cables having high-heat and moisture resistant cross-linked polyethylene (XLP) insulation.

Cables conform to the following standards:
UL-44 for Rubber Insulated Wires and Cables
UL-854 for Service Entrance Cables
(sizes 12AWG and larger only)
ICEA S-66-524 for Cross-Linked-Thermosetting Polyethylene-Insulated Wires and Cables
Federal Specification J-C-30A

APPLICATIONS

UL listed and OSHA acceptable. In accordance with Article 338 of the National Electrical Code (and subject to local code requirements), Type USE may be used as underground service entrance cable for installation underground in wet locations. As Type RHW-RHH, cable may be used for general purpose wiring for installation in wet or dry locations, in air, conduit, duct or other recognized raceways.

Maximum Conductor Temperature and Voltage Rating:

Type	Wet	Dry	Voltage
USE	75°C	90°C	600V
RHW	75°C	75°C	600V
RHH	—	90°C	600V

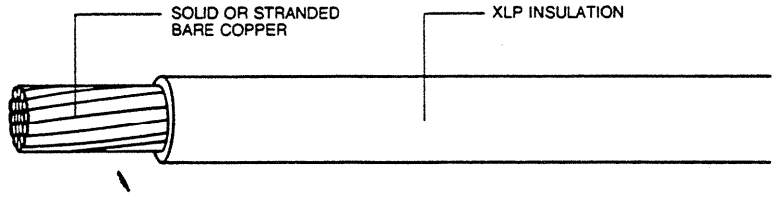
CONSTRUCTION

Conductors
Bare, soft annealed copper per ASTM B-3
Sizes 14 – 10AWG
Solid or concentric stranded (class B)
ASTM B-3 or ASTM B-8 and
UL-44 and UL-854
Sizes 8AWG – 1000MCM
Concentric, compressed stranded (class B)
ASTM B-8, UL-44 and UL-854
(An opaque separator is applied between stranded conductors and the insulation to facilitate stripping.)

Insulation
Cross-linked polyethylene (XLP)
UL-44 and UL-854

Cable Identification
Surface print
Size 14AWG (RHH-RHW only)
"14AWG Type RHH or RHW Amerlink-X 600V A.I.W. Corp. (UL)"
Sizes 12AWG – 1000MCM (USE-RHH-RHW)
"(size) AWG (or MCM) Type USE or RHH or RHW 600V Amerlink-X A.I.W. Corp. (UL)"

Construction Options
Consult factory for cable specifications with VW-1 XLP or VW-1 EPR/Hypalon insulation, Gasoline and Oil Resistant, Sunlight Resistant, and/or suitable for "Cable Tray Use" (sizes 250MCM or larger).



CABLE DATA

ES-03117 (for 14AWG) • ES-04025 (for 12AWG-1000MCM)

SIZE (AWG OR MCM)	STRANDS NO./O.D. (INCHES)	XLP INSUL. THICK. (INCHES)	APPROX. OUTSIDE DIAMETER (INCHES)	AMPACITY[1]		APPROX. WEIGHT 1000 FT. (POUNDS)	STANDARD PUT-UPS[2]	STOCK COLORS[3]
				USE/RHW 75°C	RHH 90°C			
14‡	Solid	.045	.170	15	15	22	S500/R2500	0
12	Solid	.045	.175	20	20	30	S500/R2500	0
10	Solid	.045	.196	30	30	43	S500/R2500	0
14‡	7/.0242	.045	.175	15	15	25	S500/R2500	0
12	7/.0305	.045	.188	20	20	32	S500/R2500	0
10	7/.0385	.045	.212	30	30	45	S500/R2500	0
8	7/.0486	.060	.271	50	55	73	R500/R1000	0
6	7/.0612	.060	.309	65	75	107	R500/R1000	0
4	7/.0772	.060	.356	85	95	160	R500/R1000	0
3	7/.0867	.060	.383	100	110	197	—	—
2	7/.0974	.060	.415	115	130	242	R500/R1000	0
1	19/.0664	.080	.498	130	150	314	R500/R1000	0
1/0	19/.0745	.080	.538	150	170	386	R500/R1000	0
2/0	19/.0837	.080	.582	175	195	477	R500/R1000	0
3/0	19/.0940	.080	.632	200	225	591	R500/R1000	0
4/0	19/.1055	.080	.688	230	260	733	R500/R1000	0
250	37/.0822	.095	.764	255	290	872	R500/R1000	0
300	37/.0900	.095	.817	285	320	1037	R500/R1000	0
350	37/.0973	.095	.867	310	350	1200	R500/R1000	0
400	37/.1040	.095	.912	335	380	1272	R500/R1000	0
500	37/.1162	.095	.995	380	430	1682	R500/R1000	0
600	61/.0992	.110	1.104	420	475	2113	R500/R1000	0
750	61/.1109	.110	1.206	475	535	2515	R500/R1000	0
1000	61/.1280	.110	1.355	545	615	3464	—	—

‡Size 14AWG is rated RHW-RHH only.

[1]Allowable ampacity of not more than three conductors in raceway or cable or earth (directly buried), based on ambient temperature of 30°C (86°F), per Table 310-16 of the 1987 National Electrical Code (NFPA 70-1987).

[2]**Standard Put-Ups:**
S — Spools, R — Reels

[3]**Colors:**
0 — Black
1 — White
2 — Red
3 — Green
4 — Orange
5 — Blue
7 — Grey
8 — Yellow
9 — Brown

Nonstock colors available upon request. Consult factory.

The data listed above is approximate and subject to normal manufacturing tolerances. Specifications are subject to change without notice.

CONSULT FACTORY FOR ALTERNATIVE CONSTRUCTIONS OR MATERIALS

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