CABLES,
LEADWIRE & CONDUIT
INSTALLATION

SPECIAL NOTE

READ THIS ENTIRE BOOKLET BEFORE PROCEEDING WITH THE INSTALLATION

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1. TEMPERATURE CABLES

The purpose of a *Temperature Cable* is to put *Sensing Points* down into stored grain mass. *Cables* must be hung from the ceiling of the bin attached to beams, trusses or special mounting braces. On large diameter tanks it is necessary to tie the bottom end of the cable to the bin floor to prevent a tendency for the cables to drift with the shifting grain.

1.1. CONSTRUCTION

A *Temperature Cable* is made up of several components that are extruded together into a single unit.

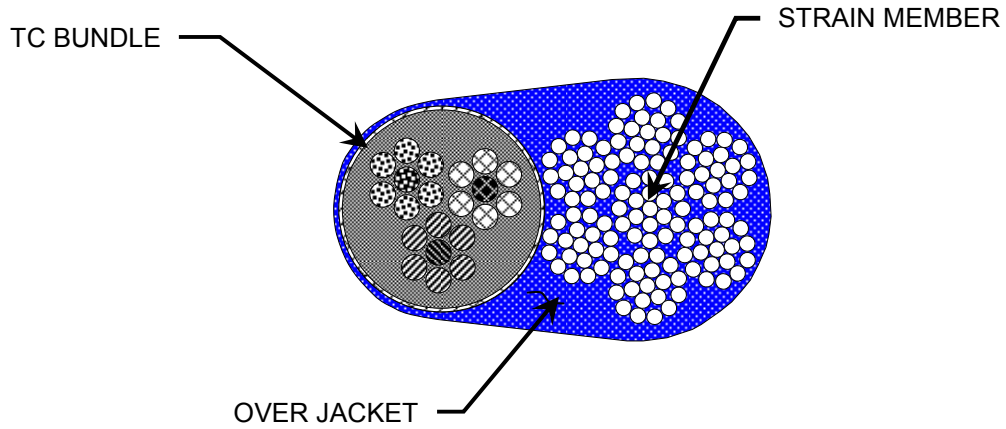


Figure 1 Cross-Section View of a Temperature Cable

1.1.1. Strain Member

The inner strain member (steel rope) provides strength against tensile and lateral forces encountered in stored grain vessels.

1.1.2. Thermocouple, TC Bundle

The thermocouple bundle contains all of the thermocouple reading points needed to monitor the grain.

1.1.3. Over Jacket

The outer covering or *Over Jacket* provides a resilient and durable protective cover that binds the strain member and the thermocouple bundle into a single unit. This covering also protects the thermocouple bundle from abuse and abrasion.

1.1.4. Sensing Points

Temperature cables contain the individual thermocouples, which are distributed at regular intervals along its length. This puts reading points evenly distributed throughout the grain mass. ThermoCouples are abbreviated *TC*.

1.2. HARDWARE FITTINGS

Before a *Cable* can be installed it must be cut to correct length, fitted with hardware to make hanging easier, and pre-attached to a length of Leadwire.

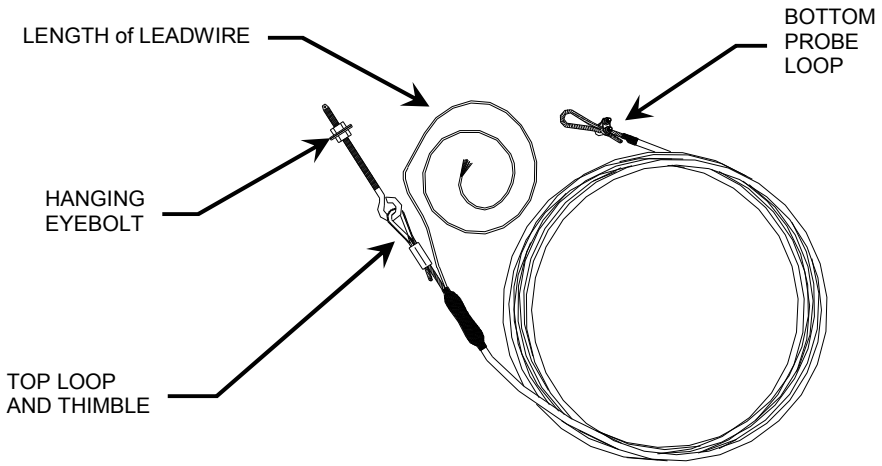


Figure 2 A Coiled Temperature Cable before installation

1.2.1. Top Loop And Thimble

The top loop and thimble provide a universal anchoring point from which to support the cable.

1.2.2. Hanging Eyebolt

A convenient fastener to aid in hanging from the interior of the structure

1.2.3. Bottom Probe Loop

The bottom probe loop provides an anchoring point from which an anchor plate, weight or other fusible tie down device can be attached.

1.2.4. Length of Leadwire

To facilitate easier installation, most fabricated Cables from the factory come with a pre-attached, Length of Leadwire long enough to reach to the first splicing location.

2. THERMOCOUPLE LEADWIRE

Thermocouple Leadwire is a multi-conductor extension cable used to lengthen connections between *Temperature Cables* and a *Remote Cable Switch*. Temperature signals of a single *Temperature Cable* are channeled through a *Remote Cable Switch*. Leadwire is used because it is less costly than Thermocouple Junction Wire. Modern electronic instruments are designed such that the length of the extension wire will not affect the temperature reading.

Each Cable typically has its own designated leadwire. This leadwire is of a special composition consisting of a common constantan wire and a group of copper wires that are dedicated to each individual thermocouple within the cable. Thermocouple leadwire is required in order to carry thermocouple signals.

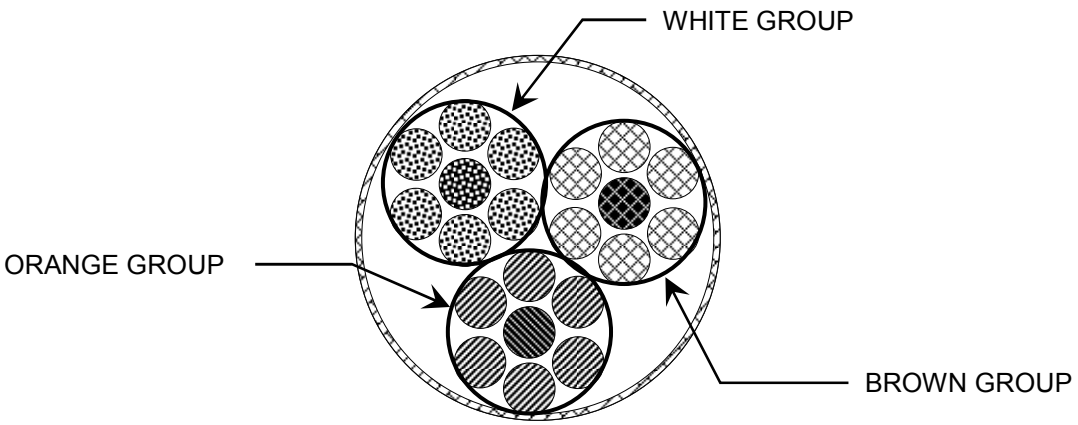


Figure 3 18-TC Leadwire Cross-Section Showing Constantan Groupings

3. CABLE INSTALLATION

Care must be taken to hang the correct length cables in respective bins. Check cable length with the project plan supplied to correspond with proper height of respective bin. See tag on cable for length. An ideal time to hang cables in a steel tank is when the roof is assembled on the ground before erection. The cables can be hung either thru the roof with "I" bolts or hung from tank reinforcements. Leadwire can be routed thru reinforcements and fastened with plastic tie bands, thus keeping leadwire from sagging and getting into the grain.

3.1. IN STEEL TANKS (BINS)

There are several types of steel tanks and parts of these instructions may be modified to fit the circumstances. Care should be taken in handling the cables and leadwire to avoid crushing, cuts and knots. Cables should be sorted according to length and put in the respective tanks before adding other hardware.

3.1.1. Use Caution When Planning Where To Hang Cables

The cables must be hung according to the bin manufacturer's specifications. Due to the many differences between steel tanks, no specific location instructions can be given. In most cases, the roof itself is not strong enough to support the cables. Some have beams or trusses; and some have special braces for hanging cables. If the cables are not properly hung, the bin roof and sidewalls can be damaged by the pull of the cables. Refer to bin manufacturer's recommendations to determine the structural strength of the bin or cable supports supplied by the manufacturer to be sure that it is adequate and will not permit damage to the roof or sidewalls. The client is totally responsible that the steel bin is of proper design and strength to support the temperature detection cables.

3.1.2. Assigning Cable Numbers

This general numbering sequence of cables is standardized for round steel tanks. Specific layouts will be prepared for other buildings.

Number each leadwire to correspond with the cable layout print with a "Brady" number about 18 inches from each end. If more than one radius is required by the coverage pattern, the inner circle will have the smaller numbers in clockwise sequence and the lowest number of the other radii will be the first cable clockwise from the ladder. See Figure 4.

3.1.2.1. Cable № 1, First From Ladder

Number one will be on the inside circle of cables. Cables are numbered clockwise looking down from the top. The center cable or first cable clockwise from the ladder is always number 1.

3.1.2.2. Avoid Fill Streams

Locate the position for the respective cables on the bin top, making sure that no cables will be hanging in the grain stream when the bins are being filled.

3.1.2.3. Sloped Roofs

If the roof is sloped, arrange the cables according to length. The shortest cables are for the outer circle and the longest are for the inner circle.

3.1.2.4. Order Of Layout

Lay the outer circle of cables on the bottom of the steel tank in line with the hanging points, but next to the wall. Lay the inner circle of cables on the bottom of the steel tank in line with their hanging points, but about 10 feet (3 meters) to the outside.

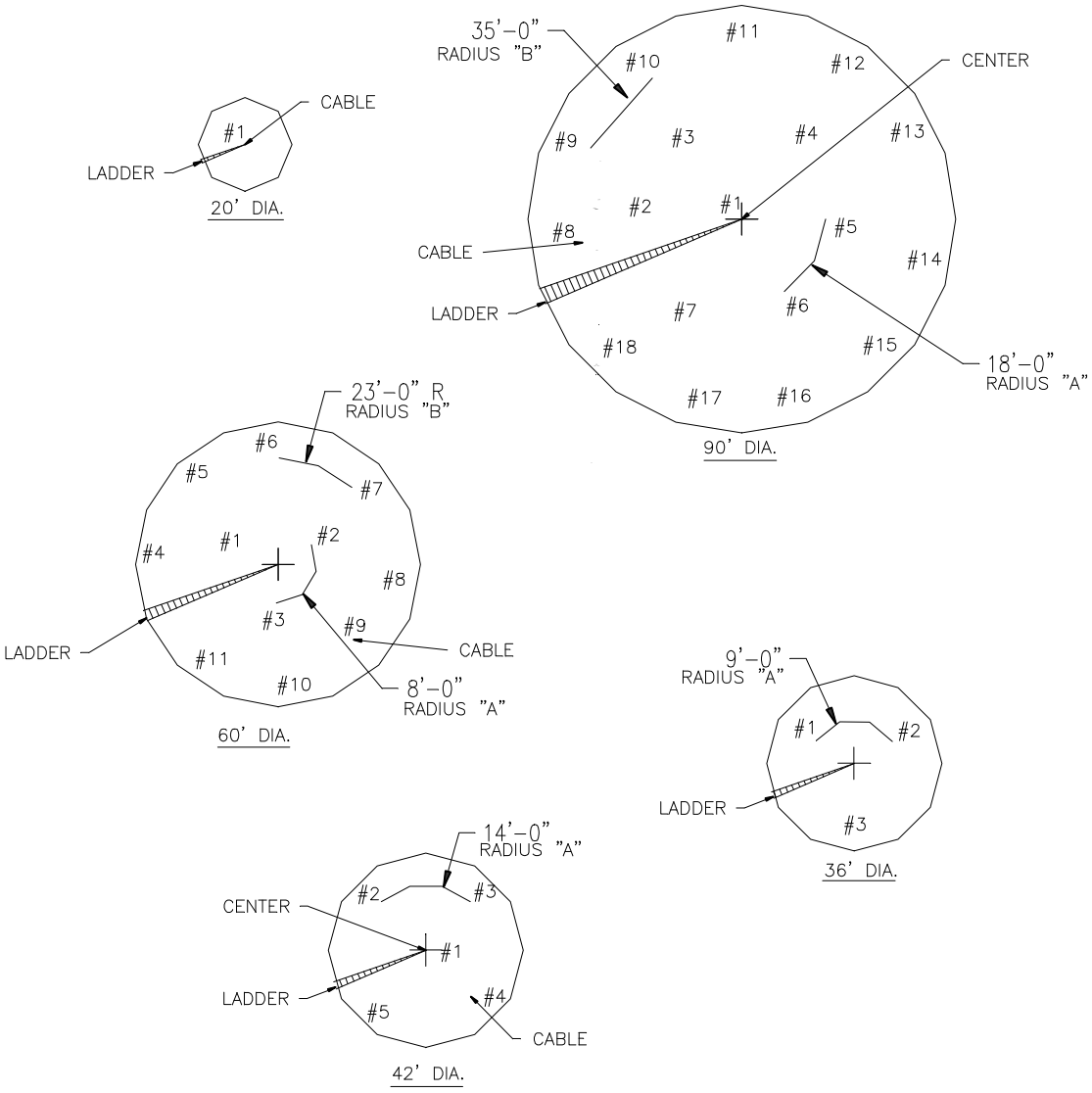


Figure 4 Cable Numbering Sequence of Storage Tanks

3.1.3. Fasten the Top of Cable to the Roof Structure (Hang)

Place the eyebolt through the hole, in the beam, roof support or roof where the cable should be hung. See Figures 5 & 6. In some tanks, angle or channel is used to span roof ribs for load distribution.

3.1.3.1. Secure the Eyebolt

Tape leadwire to eyebolt. Leave enough slack in leadwire so that the cable may swing without pulling splice at top of cable apart.

3.1.3.2. Secure Nut and Washer

Screw one nut and washer down on the eyebolt just above where the leadwire is taped.

3.1.3.3. Seal Hole in Roof

If the roof itself is drilled through; seal the roof, the washer, the nut and eyebolt with roofing cement to prevent water leaks.

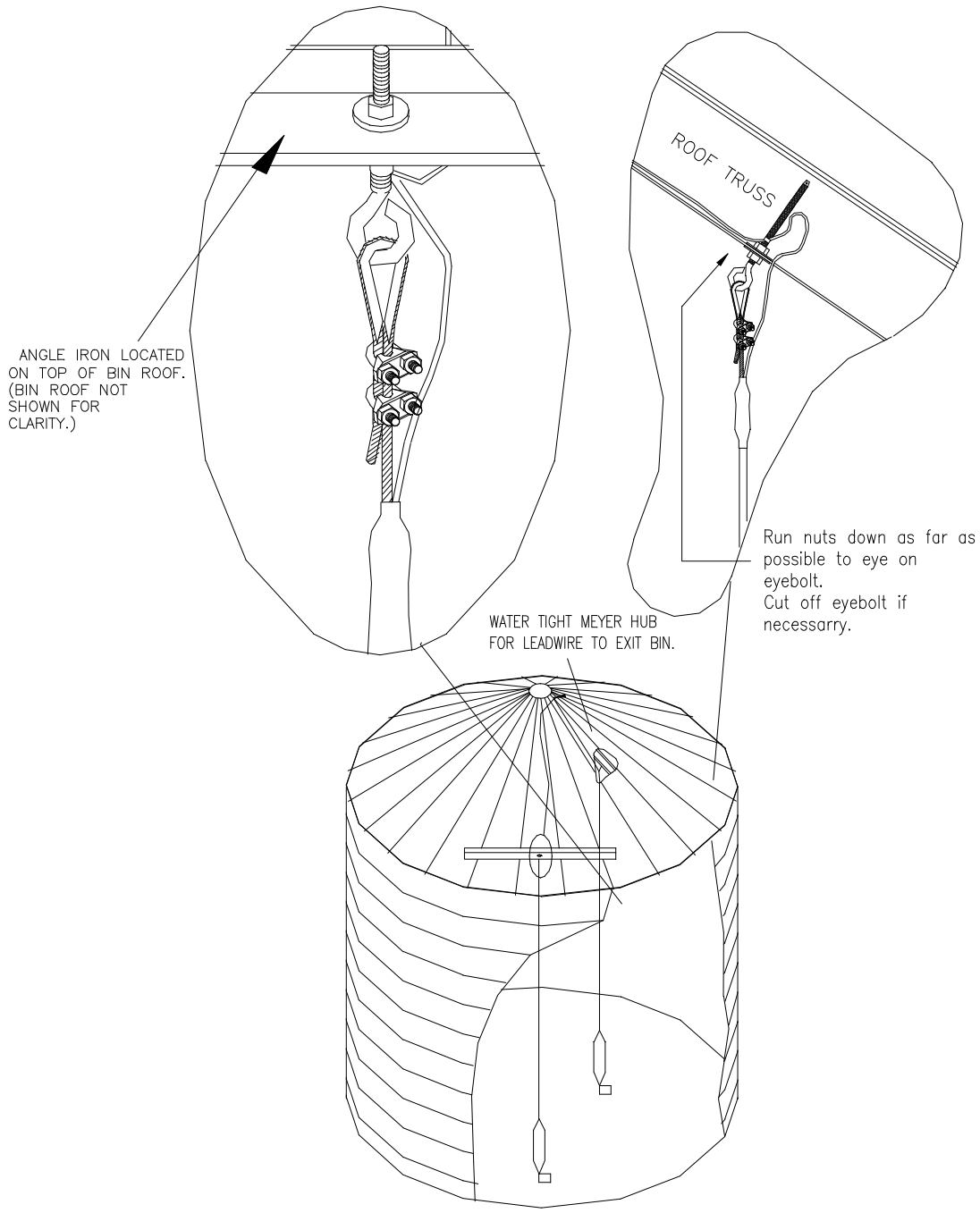


Figure 5 Steel Tank Cable Installation

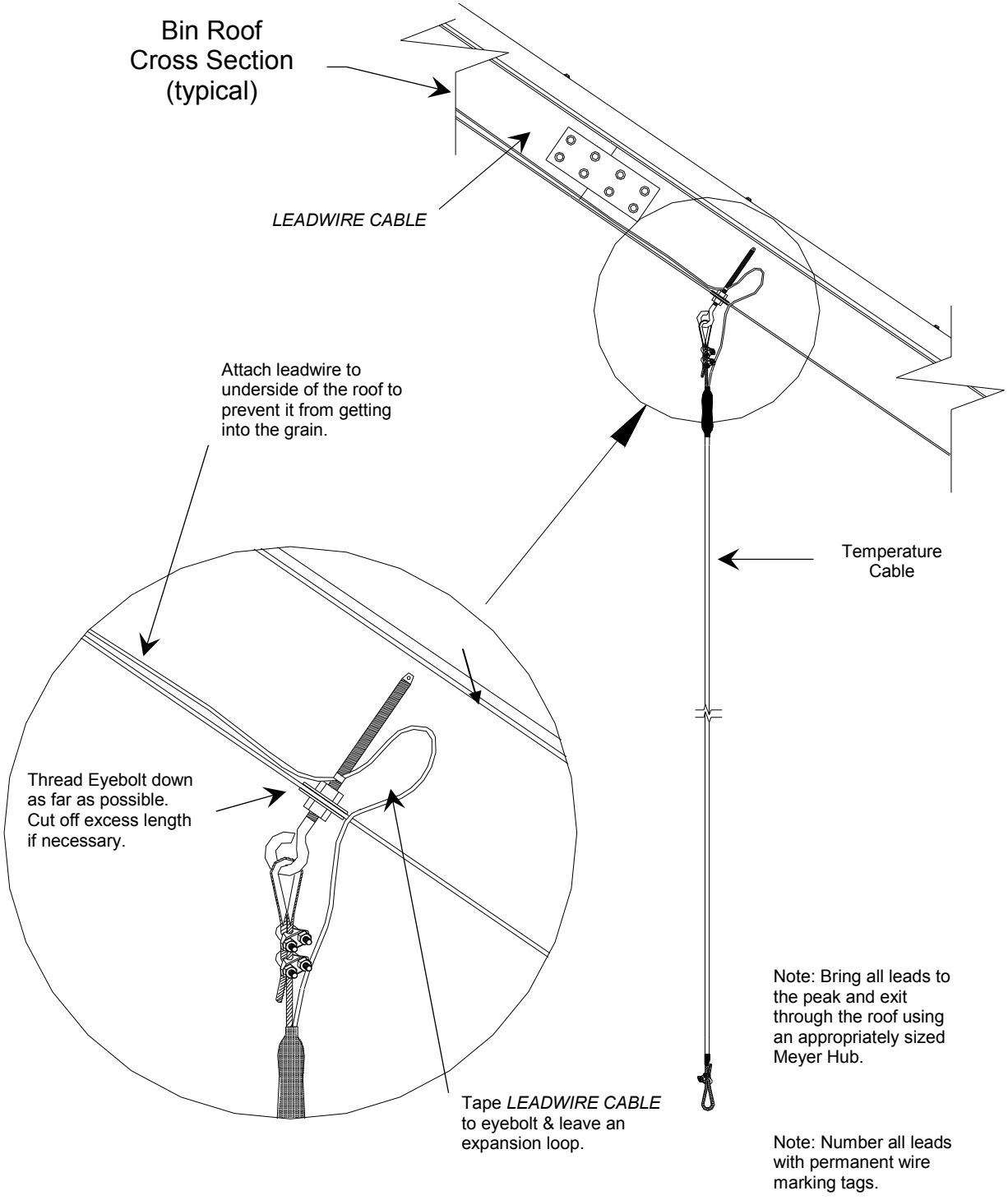


Figure 6 Typical Cable Hanging Details

3.1.4. Fasten Bottom of Cable to Floor (Tie-Down)

Tie the bottom of the cable to the anchor plate, using the loop at the bottom of the cable and hole in the anchor plate; Figures 7 & 8. See Figures 11 – 15 for other tie-down methods. Use a maximum of 110 lb fishing line or baling twine. This will hold the cable in place while the bin is filling.

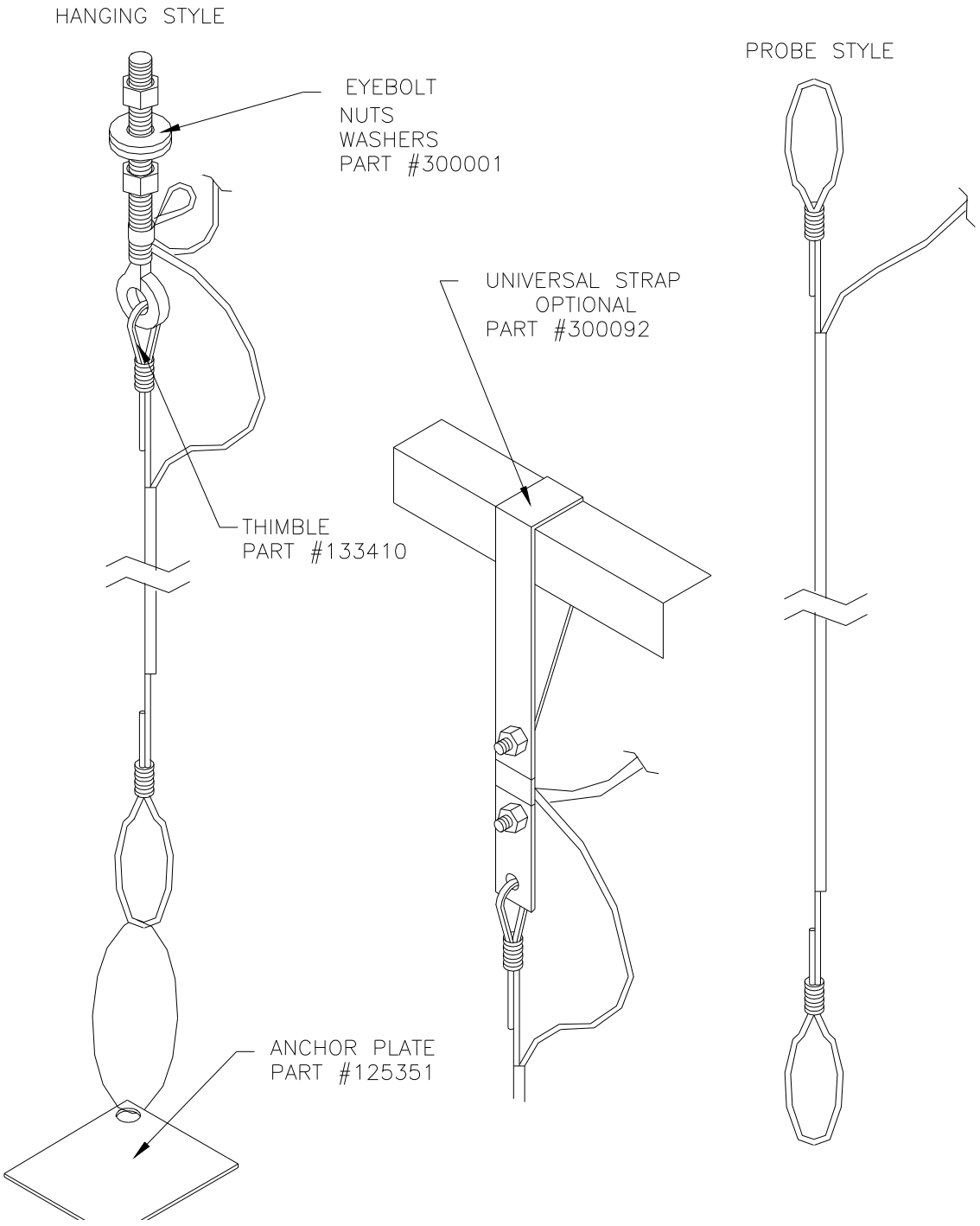


FIGURE 7 Typical 6-TC Cable

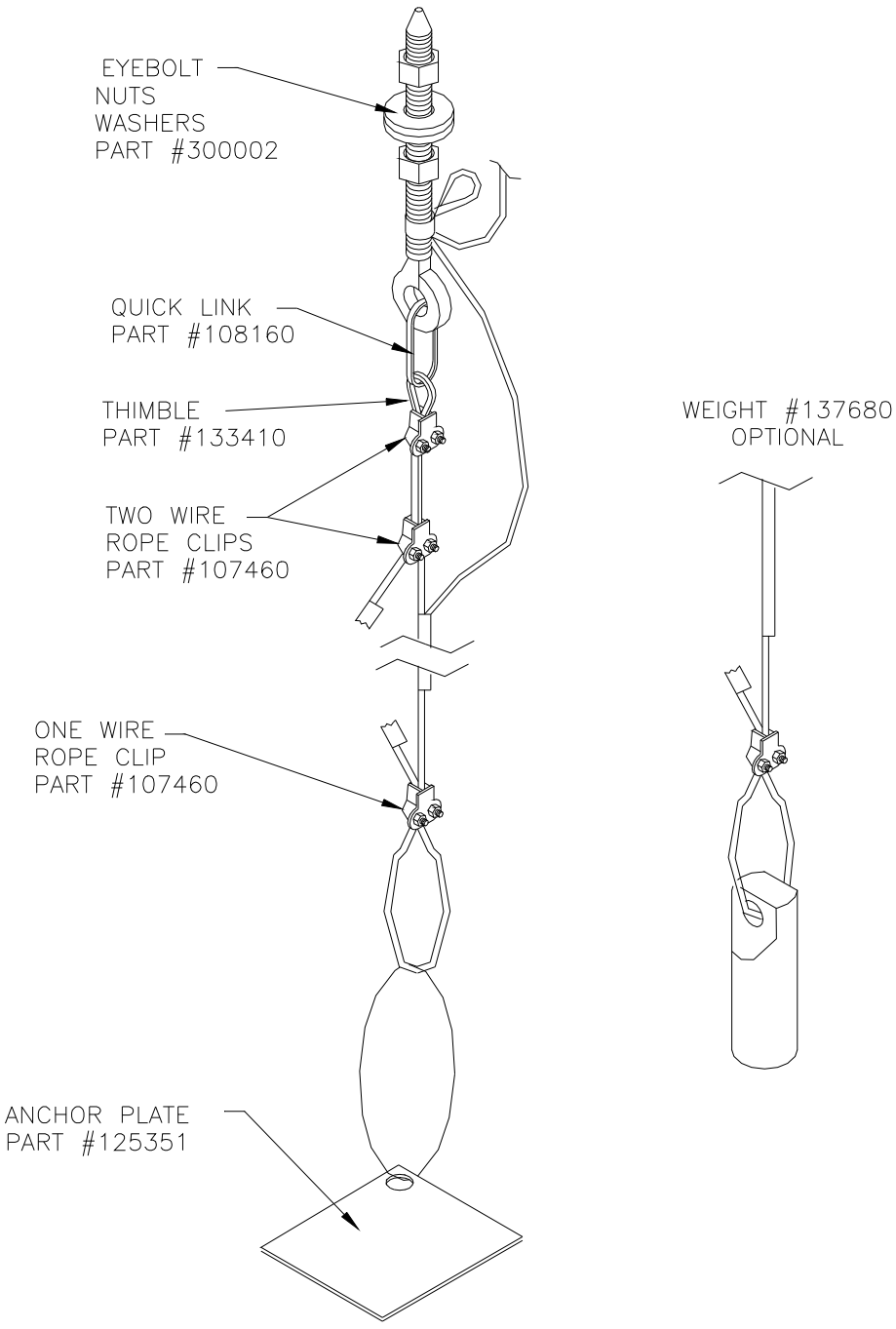


Figure 8 Typical 12-TC Cable

3.2. IN CONCRETE STORAGE BINS

3.2.1. Concrete Structure WITHOUT Hanger Boxes

3.2.1.1. Lay Out Of Holes

Lay out of holes for the hangers are very important. The cable must be hung approximately in the center of the bin, or as per print furnished with the cables. However, the cable must not be hung in the grain fill stream, nor hung nearer than one foot to any obstruction such as a beam. This is so normal movement of the cable will not chafe the cable or leadwire.

3.2.1.2. Holes To Drill In One Day

When drilling the hanger holes, make sure not to drill more holes than can be used in one day without making provision for waterproofing overnight if there is grain in the bin.

3.2.1.3. Countersinking In Floors

In concrete storage, if the hole is inside the gallery or headhouse, the hole must be countersunk enough to allow the eyebolt top to be flush with the floor. After hanging the cable, the holes are to be filled with silicon sealer.

3.2.1.4. Fasten the Top of Cable to the Roof Structure (Hang)

The cable assembly is drawn up with a wire or chain through the eyebolt tip. A large washer and nut are put on top for load distribution. The inside installation is countersunk to keep the bolt tip out of the way. The leadwire is taped to the eyebolt to prevent strain on the splice. When the installation is outside, roofing mastic is applied under and over the washer to make it waterproof.

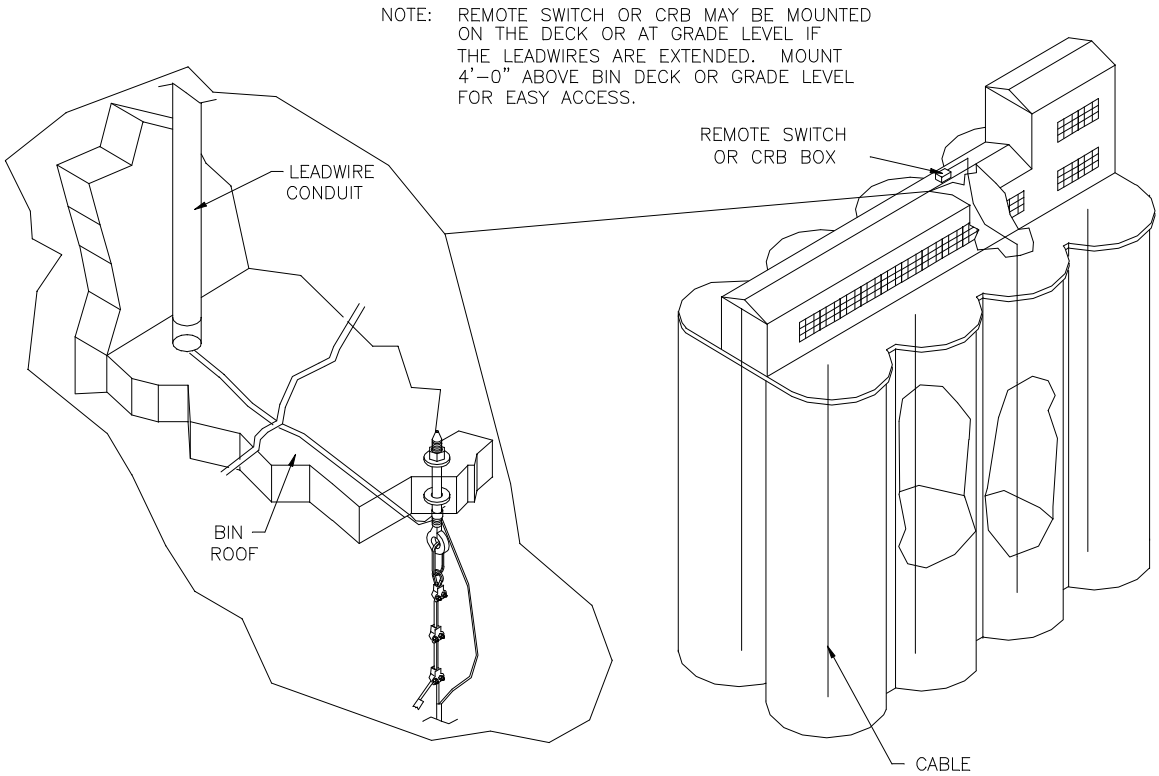


Figure 9 Concrete Tank Cable Installation

3.2.2. Concrete Structure WITH Hanger Boxes

The concrete hanger box is installed during construction. The box is placed on the form in the proper place before pouring. A 5/8" x 30" rod is run through the box for the hanger.

Two types of cable hardware are normally used to hang the cables, strain clamps and quicklinks.

3.2.2.1. Strain Clamp

If the cable has a strain clamp, remove the cotter key from the pin in the hanger and slip the pin out. Lower the cable hanger slightly below the 5/8" steel rod, and then raise it so that an "ear" is on each side of steel rod. Replace pin and cotter key. The design of the cotter key makes it unnecessary to spread the ends.

3.2.2.2. Quicklink

If the cable has a quicklink, loosen the opening of the quicklink. Place the quicklink over the 5/8" steel rod and tighten the latching nut. Insert the bottom of the Hot Spot cable through the hanger box on either side of the 5/8" steel rod. Uncoil the cable and lower into bin, being careful not to tangle, scrape, or otherwise damage it.

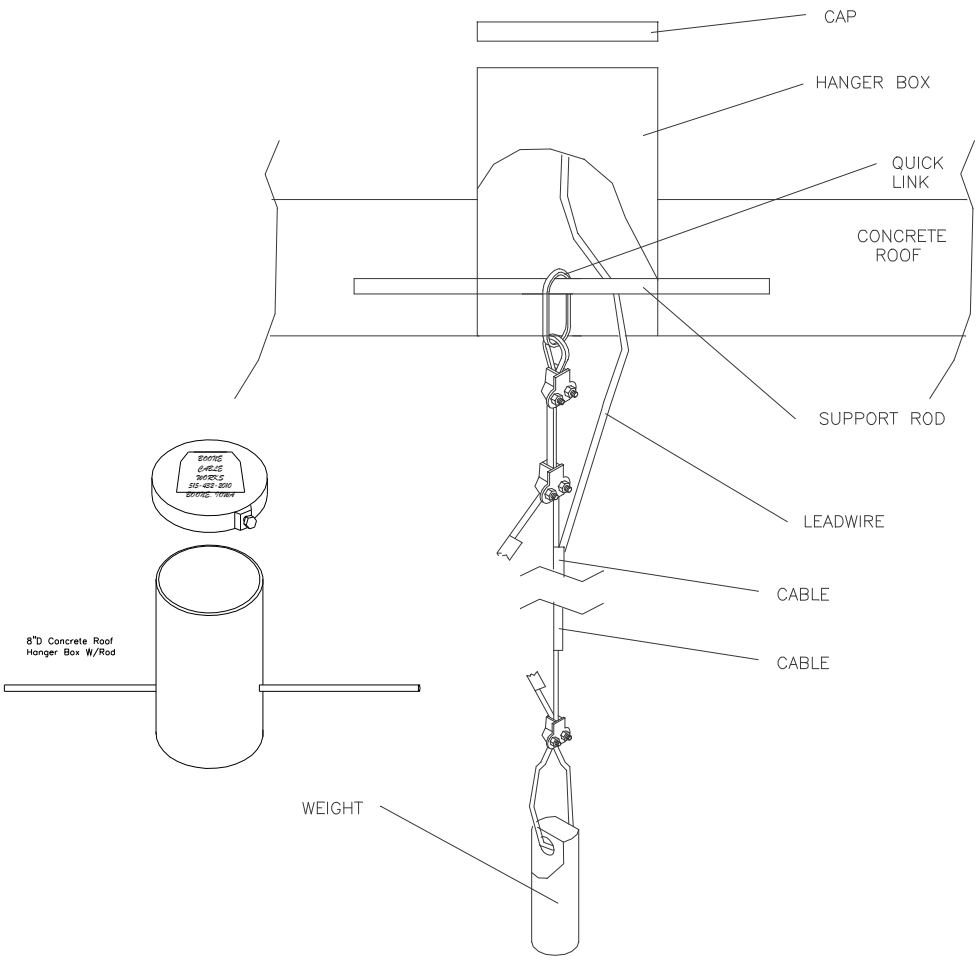


Figure 10 Cable Hanging Inside Concrete Hanger Box

3.3. CABLE TIE-DOWN METHODS

On large diameter steel or concrete tanks, there is a tendency for the cables to drift to the outside of the tank during filling. This same thing occurs when truck or rail load out spouts are located in tank sidewall, only in this case the cables often times come out the spout.

To correct this *Drift* or *Out-The-Spout* condition, it is necessary to tie the cables to the bin floor. This can be done in several ways depending on type of floor is flat or hoppered. The existence of a sweep auger, aeration duct, or flush duct will also change the tie down method. Refer to Figures 11-15.

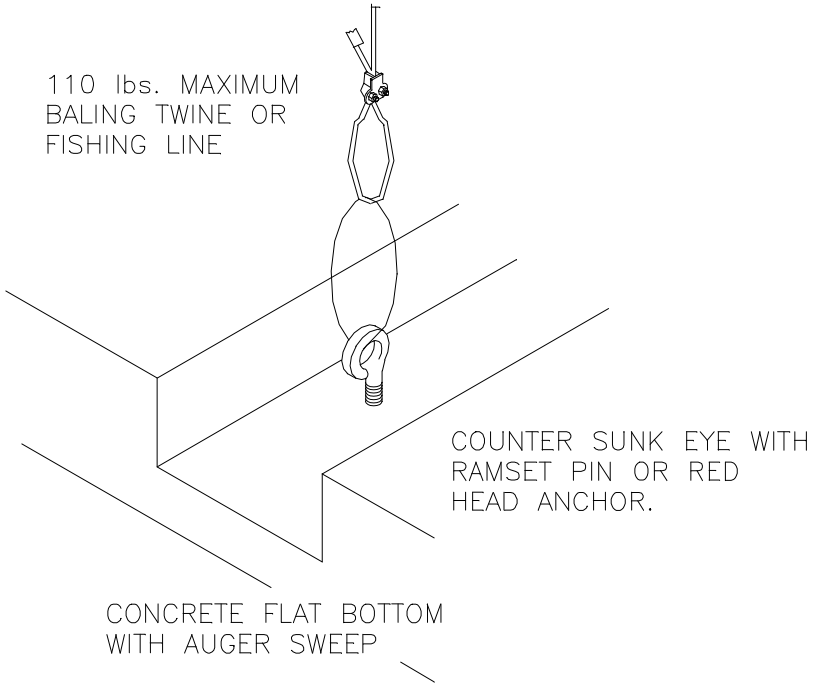


Figure 11 Counter-Sunk Flat Bottom Tie Down

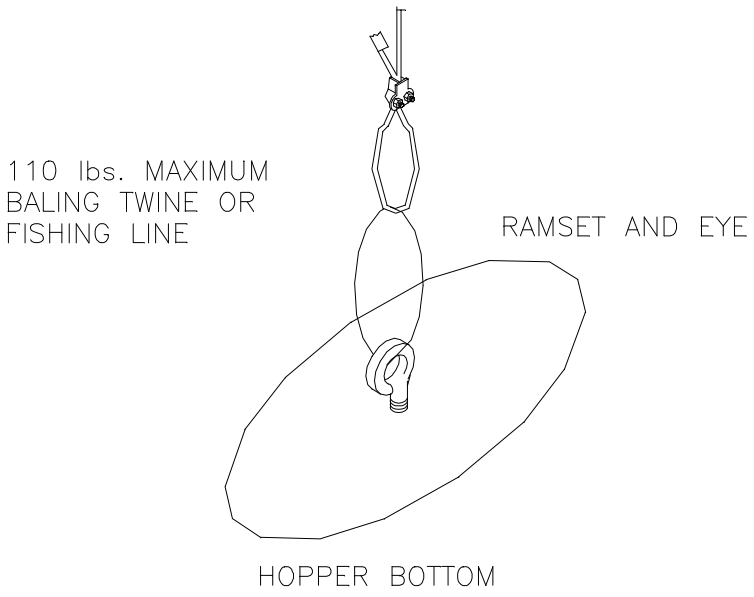


Figure 12 Hopper- Bottom Tie Down

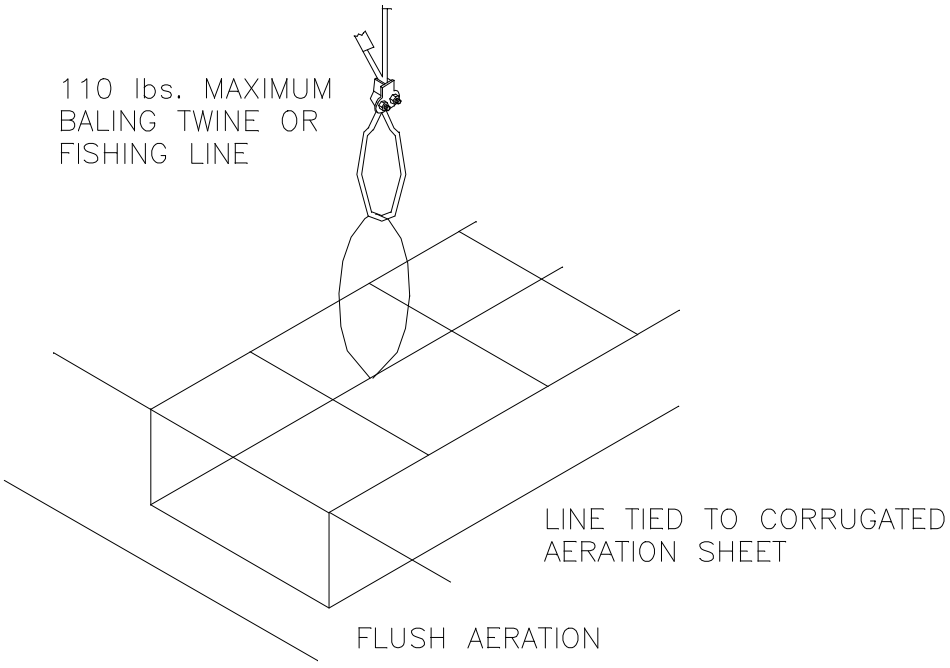


Figure 13 Flush-Duct Tie Down

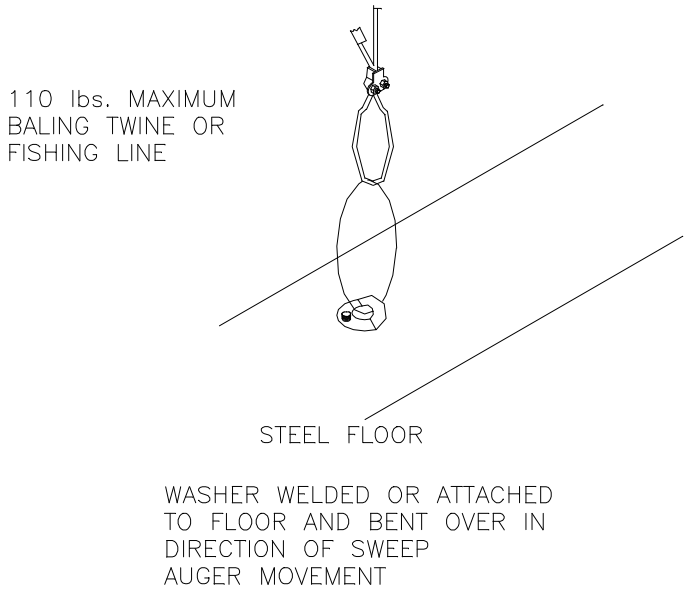


Figure 14 Bent Washer Tie Down

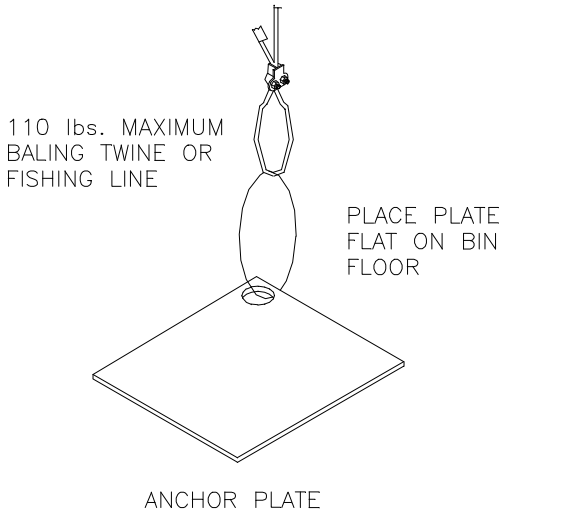


Figure 15 Anchor Plate Tie Down

4. CONDUIT

Conduit is used to protect wires from weather or mechanical damage. Thin wall conduit is usually used for inside runs which will not be exposed to the weather. Threaded rigid conduit must be used for any outside work which will be exposed to the weather, and may be required on some installation for inside runs as well.

4.1. SELECTING SIZE OF CONDUIT

Conduit size is determined by the maximum number of leadwires which must run through it and the size of the leadwire. The maximum should be 75% filled. Proper type and size of fittings must be used in each raceway for ease in pulling wires.

Table 1 Maximum Number Of Leadwire Cables That Can Fit In Conduit Sizes

NOMINAL CONDUIT SIZE (DIAMETER)		Maximum № Of Leadwire Cables per Conduit Size				Interior cross-sectional area of conduit	
ENGLISH, INCH	METRIC EQUIVALENT, mm	6-TC	12-TC	18-TC	21-TC	inches	mm^2
1/2"	16	9	3	3	3	0.12	77
3/4"	21	16	5	5	5	0.21	135
1"	27	27	12	12	12	0.34	219
1-1/4"	35	50	20	18	18	0.60	387
1-1/2"	41	70	30	28	28	0.82	529
2"	53	100	60	46	46	1.34	865

4.2. INSTALLING CONDUIT

4.2.1. Separation From High-Voltage

All conduit runs must be kept away from high-voltage wires as much as possible to prevent inductance "pick-up".

4.2.2. Total Number Of Bends

No more than two 90 degree bends or combination of bends totaling 180 degrees should be in the raceway between pull boxes.

4.2.3. General Raceway Requirements

Requirements regarding perpendiculars, horizontal, supports, fittings, and "expansion joints" are the same as for general electrical work.

4.2.4. Sealing Joints

When conduit is exposed to weather, joint compound and proper gaskets must be used; special precautions should be taken to keep moisture out of the conduit, so control wire and/or leadwire are kept dry.

4.3. SPLICE ENCLOSURES

Wire-To-Wire Splicing Wire-to-wire splicing should be done inside a splice box or in a condulet fitting. A splicing enclosure will provide mechanical protection from collateral damage related to moving machinery, or vigorous housekeeping. The splice is more vulnerable to environmental effects and physical damage than the remainder of the wire run, which is still in its jacket. A splice enclosure also keeps them free of dirt and moisture. Splicing enclosures should be placed in an easily accessible location and has a proper dust tight cover. See Figure 16.

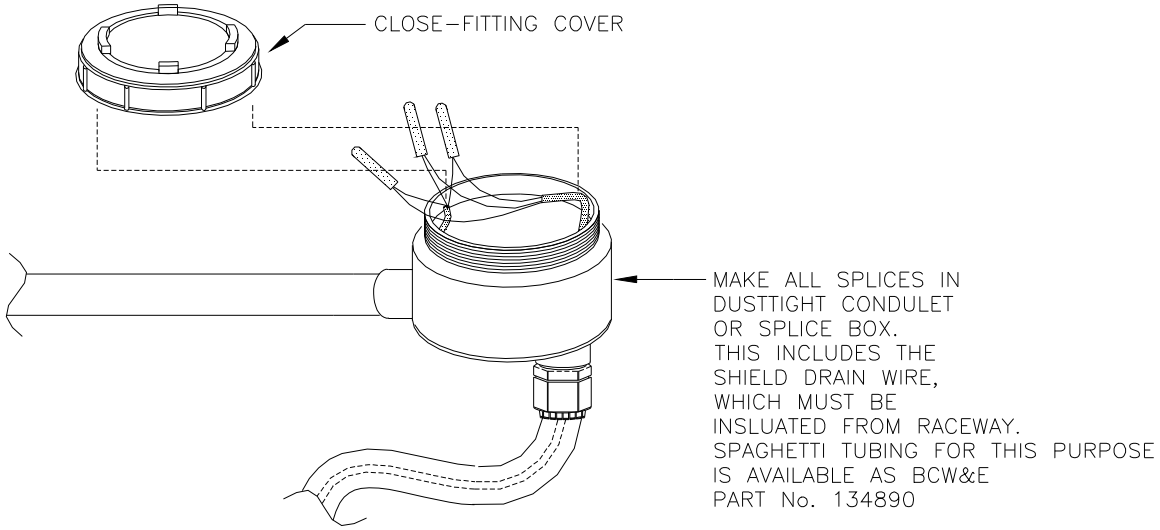


Figure 16 Splicing in an Enclosure or Fitting

5. LEADWIRE

5.1. RUN LEADWIRE

Leadwire should be run in accordance with the system plan drawing. A short length of leadwire is attached to each cable at the factory. There should be as few splices as possible. Plan the runs so that all splices will be made in places where they are readily accessible. Leadwire must be handled with care when installing. Special care should be given so the leadwire is not nicked when it is pulled through the conduit. Leave extra leadwire where splices will occur to make neat splices. A length of at least 5 feet is recommended. The Brady numbering tags should be moved up before trimming leadwire. This is important to keep the leadwire labeled correctly.

5.2. SPLICING LEADWIRES

Leadwire splices are very important to the integrity of the system. Open Thermocouples (OT's) will occur in the system if the splices are not correct. Splices must only be made in pull boxes, condulets or where a leadwire run is terminated, such as an *Interface* or *Remote Cable Switch*. The leadwires for a *Remote Cable Switch* are numbered from 1 to 24 for easy identification when splicing to *Cable Leadwire*. Splices must not be pulled into the conduit. Refer to document titled “REMOTE CABLE SWITCHES” for further instructions concerning connections.

All leadwire splices made by the installation personnel will be made color-to-color and group-to-group. Never change the factory-made connections at the top of the cable. Splices at the top of the temperature cable are not color-to-color generally.

5.2.1. Tools Required

5.2.1.1. Compression Tool - available through ROLFES @ Boone P/N 109510
5.2.1.2. ST 100 SERIES WIRE STRIPER
5.2.1.3. Diagonal Cutting Pliers
5.2.1.4. Long Nose Pliers
5.2.1.5. Knife

5.2.2. Material Required

5.2.2.1. Line B Grease Filled Crimps

The crimps are insulated outside offer a higher degree of insulation from moisture than soldering, due to the grease filled liner. They are also effective in hazardous areas where soldering equipment is not allowed or due to remoteness of electrical power. They also have the added benefit of not requiring the stripping of the insulation from the individual conductors when connecting two 26 AWG wires. (ROLFES @ Boone P/N 109512)

5.2.2.2. Electrical Tape

After the splice bundle is completed, several wraps of good quality electrical tape will provide abrasion resistance, and make for a neat looking splice.

5.2.3. Detailed Steps

The detailed steps listed below to make splices use an 18-TC leadwire as the example. These same instructions can be used also for 6-TC, 12-TC and 21-TC leadwire.

5.2.3.1. Remove Outer Cable Jacket

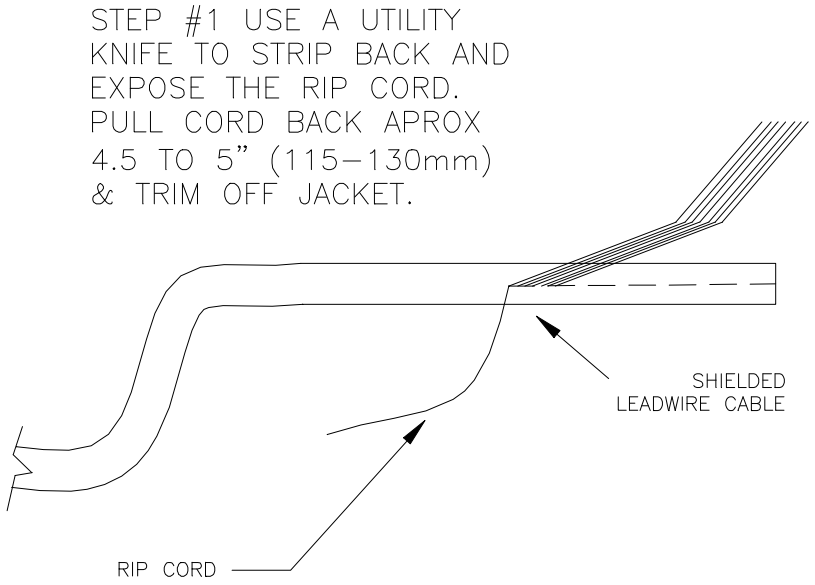


Figure 17 Removal of Outer Jacket

5.2.3.2. Separate The Three Groups In Each Leadwire

Wire bundles are grouped by the color of the insulation on the Constantan wire that is common to that collection of copper wires. Wrap the white, brown and orange wires around the wires in their respective groups. 6-TC leadwire has only one group and the constantan is white. 12-TC leadwire has to two groups with white and brown constantans. 18-TC leadwire has three groups with white, brown and orange constantans. 21-TC leadwire is also composed of three groups with the same color constantans as 18TC. 21TC leadwire has 7 wires per group instead of 6, for a total of 21 thermocouples. See Table 2.

Table 2 Organization of Leadwire Bundles by Color Group

Type of Leadwire	No. of Groups	No. of Wires per Group	Constantan Color		
			White	Brown	Orange
6-TC	1	6	●		
12-TC	2	6	●	●	
18-TC	3	6	●	●	●
21-TC	3	7	●	●	●

5.2.3.3. Match Up Ends of the Leadwires that are to be Joined.

Select the two groups (one from each leadwire) that have the WHITE identifying wire. Fold the other groups back out of the way. Check again to be sure the two groups both have the white wire.

5.2.3.4. Separate Individual Wires

Separate the individual wires of each group about 1/4" back so that the colors of each individual wire can be clearly seen. Note that all groups have a black, a blue a green, a red, a yellow, and a clear (copper-colored) wire, (21TC leadwire also has a purple wire) as well as another that may be WHITE, ORANGE, or BROWN. These white, orange, or brown wires are the constantan wires and also serve to identify the groups. See Figure 18.

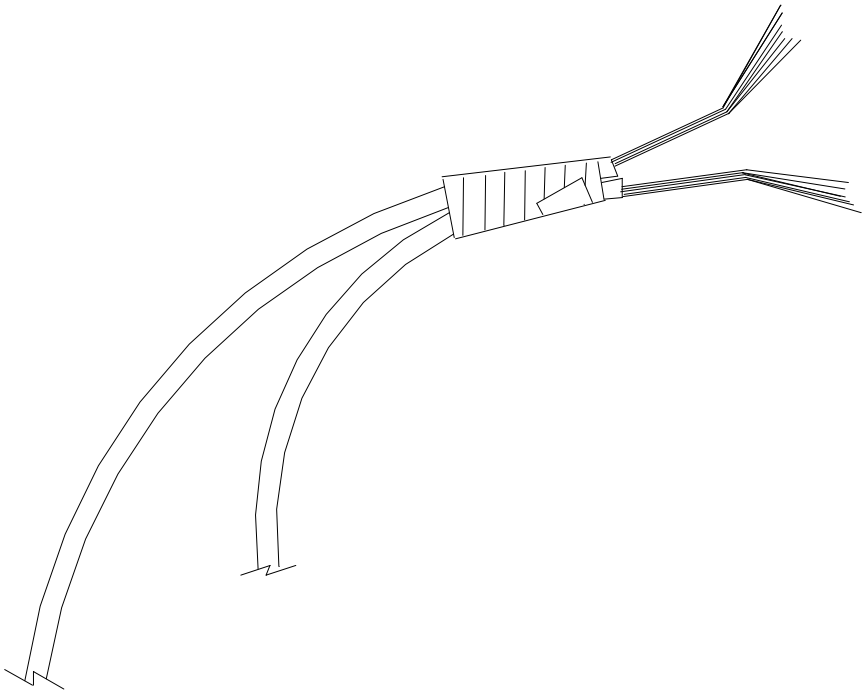


Figure 18 Separate Individual Wires of Each Group

5.2.4. Wire-To-Wire Pairs or Triples

Pair up the wires color-to-color and twist them together as in Figure 19. Trim all wire bundles to the same length of about 4.5" to 5" (115-130mm) long and separate bundles. As long as there are **no more than three wires under a crimp**, splicing can be accomplished **without stripping** the individual conductors.

5.2.5. Splicing With *Line B Grease Filled Crimps*

After all of the pairs have been twisted, slide a line B Grease filled crimp over each pair, being certain that they are fully seated. Use only the appropriate crimping tool designed for proper seating of the crimps to ensure that a good connection is made on each twisted pair. See Figure 19.

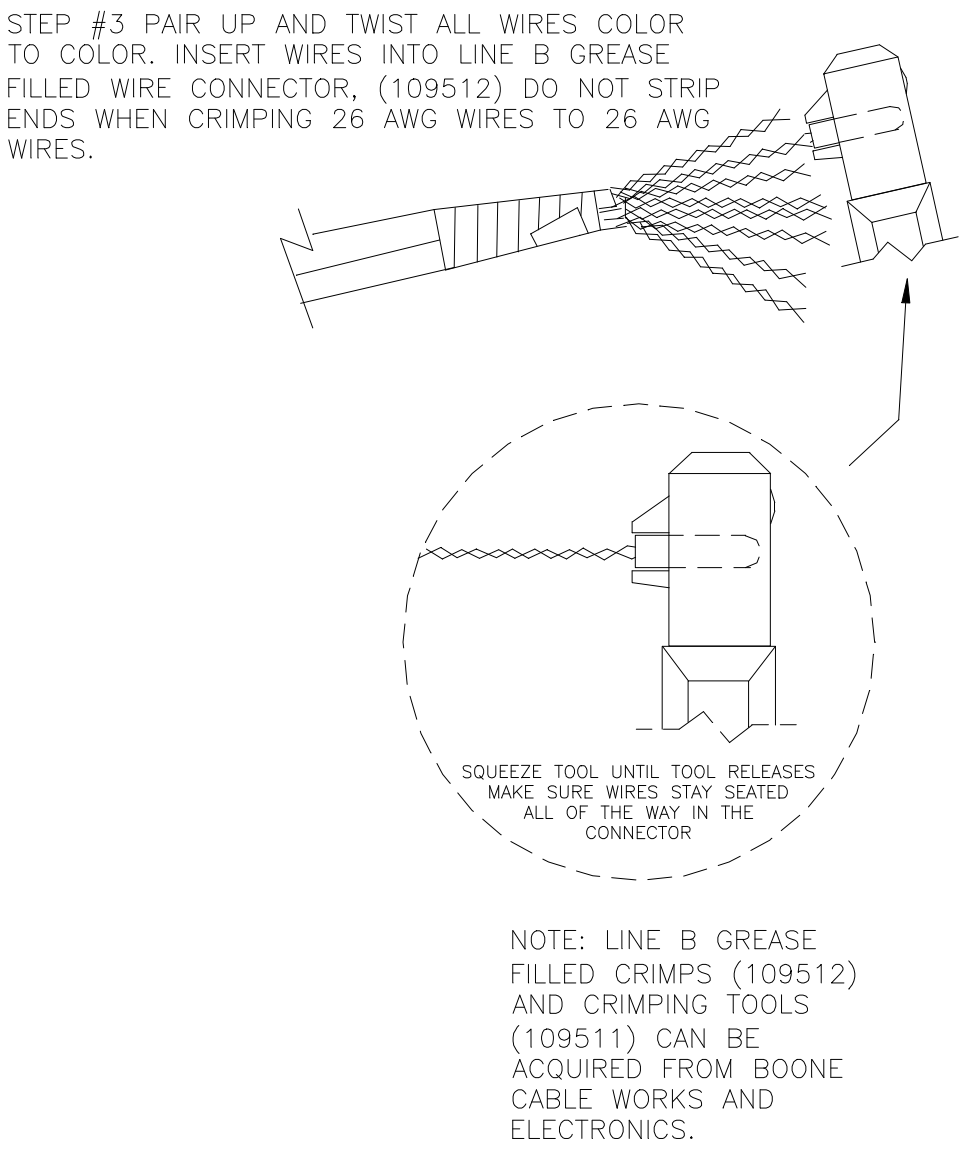
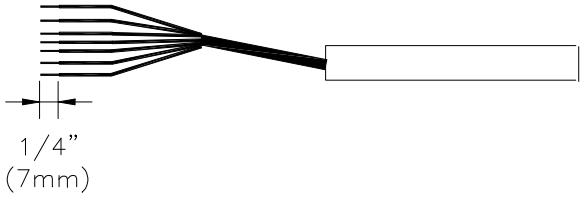


Figure 19 Cable Splicing with Crimps

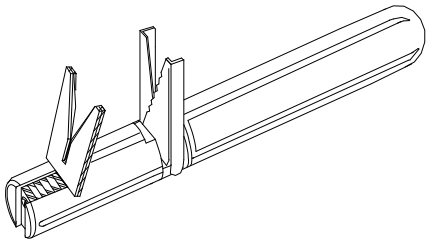
5.2.6. Four or More Wires

If **more than 3 wires** are to be spliced under the same crimp, **you must strip off the insulation** before twisting. If stripping is needed, it should be done using the appropriate tool referred to in Figure 20.



TYPICAL OF STRIPPED WIRES
READY TO INSERT INTO TERMINALS

NOTE: After trimming wires to length, slide up to 4 wires into the stripping slot at the desired length of 1/4" to 3/16" (7–10mm)& pull. Ends will now be clean and ready to insert into the terminal.



NOTE: Because the wires are only 26 AWG solid, they can't be stripped with conventional wire strippers or side cutters. This will nick the wire so that it can break very easily. We highly recomend the ST 100 stripper made specificly for 26 AWG wire. This stripper removes the insulation without nicking the wire.

ST 100 SERIES WIRE STRIPPER FOR 26 AWG WIRE AVAILABLE FROM BOONE CABLE WORKS AND ELECTRONICS.

Figure 20 Strip Insulation Off Wire Ends

5.2.7. Differing Wire Gauges

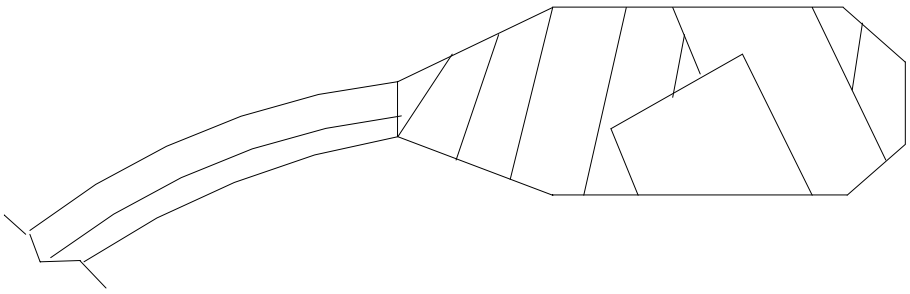
Wires of **different gauge** sizes **must be stripped**. One such connection of this type is where the Sensing Point pigtail connects to the remote extension wires. In these situations, it is necessary to strip both ends before pairing up and twisting them together. Be sure that the crimp is fully seated over the bare ends and that no bare wire is sticking out from under the crimp. Use the crimping tool and finish the connection as usual.

5.2.8. Drain Wire

Shielded leadwire cable has an uninsulated drain wire inside the outer jacket. The drain wire runs the length of the cable and acts as a grounding point for the shield. Be sure to maintain electrical continuity between all shield drain wires at each splice location, and at termination points. This shield drain wire must terminate at earth ground in the Instrument only. It should not be grounded to the conduit or other structures at splice locations. Insulate any exposed length of Drain Wire with plastic tubing (spaghetti tubing) or electrical tape. See Figure 16.

5.2.9. Wrap Splice in Electrical Tape

For the termination splice, cover the completed splice with one layer of good quality electrical tape. Overlap each turn about half-way to get a good cover. The splice is now complete. See Figure 21.



STEP#4 BUNDLE ALL SPLICES TOGETHER AND WRAP WITH A GOOD QUALITY ELECTRICAL TAPE.

Figure 21 Splice Wrapped in Electrical Tape