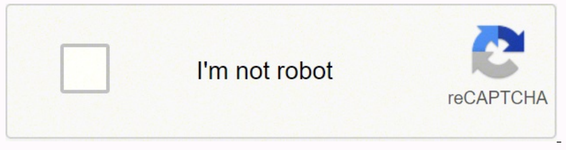

Continue

How to wiring harness

This is a basic TBI harness for all engines using ECM 1227747 and 1228746 type ECM-many others can be used. Basic connections are standard but it is easy to customize one for your needs. Typically, technical support is limited to the customer with only a harness purchase due to the complexity of variables we have no control over. Please contact us with any questions, we are here to help. We've been manufacturing cable assemblies and wiring harnesses for all types of businesses since 1979. With humble beginnings in electrical-automotive components, we have grown and adapted for new industries and emerging technologies over the years. Our operations remain entirely on-shore, and to this day, we continue to employ a highly-skilled local workforce that we can trust to deliver the best quality wiring solutions for our customers. We manufacture cable assemblies and harnesses used in communication systems for underground mining environments and HF, satellite and tactical radio systems. We make custom wiring harnesses and looms for all types of after-market accessories including gauges, sensors, spotlights, radio systems, reversing camera systems, antennas and solar upgrades. We provide custom cables looms and wiring harnesses for items such as GPS tracking systems, vehicle control systems and targeted nutrient release systems. Our cable harnesses and assemblies are in all sorts of electronic products including voltage conversion products, media and advertising displays, security monitoring and metal detection systems. We produce cable assemblies and looms for switchboards, switchgear and control panels used in residential and commercial settings. We proudly support the development of new technologies by creating bespoke cable assemblies and cable looms for medical equipment and industrial applications. We manufacture all types of custom cable assemblies, looms, and harnesses. With our dedicated team and cutting-edge technology, we can help with your project; whether it be a simple request or a complex project requiring custom tooling. We can also help with material selection and provide swift prototyping to refine your design. Whatever type of cable assembly, wire harness, or electrical loom you need, we can help. We can help with more than just custom cable assemblies and wire harnesses. Our highly skilled manufacturing team is experienced in a variety of different techniques. Whatever you need, you've got someone who can do it. © 1996-2014, Amazon.com, Inc. or its affiliates Browse our selection of Wire Harnesses. We carry wire harnesses for Leer, Century, Raider, A.R.E., and other truck toppers and camper shells. Items: 1–10 of 11 Items: 1–10 of 11 Nav Menu 2 Electrons Getting electrical signals from point A to point B is pretty standard thing...Put a piece of copper wire between A and B and the job is done. A century of development has left us with increased specialization in wiring, connection devices, and everything in between point A and B. "Mil-Spec" or military specification, has become the buzz-word in motorsport electrical harness construction. Actually motorsport wiring has developed it's own specialized connectors but it's still largely constructed from aerospace components. Perhaps "Race-Spec" will become the new buzz-word....Probably not with the trillions of dollars spent on drones, F22's, and commercial aircraft. This is not a definitive guide on building wiring harnesses as this could encompass two wheels, four wheels or no wheels. It does give you a perspective on motorsports ecu wiring and provides access to further literature for you to study and make your own decisions. We build ecu wiring harnesses for our production items and for our own racing activities. Production OEM Automotive Wiring On one end of the scale there is OEM automotive wiring, like on your new passenger vehicle or truck, wherein costs are paramount and warranties are offered, in some cases, bumper to bumper for 100,000 miles. Pictured above is a production passenger car harness in GXL and TXL wires. These vehicles and their myriad of up to sixty microprocessors, connectors, sensors, relays, and switches are tested for years on end in extremes of temperature, humidity, vibration, and electrical interference. There are no mil-spec metal shell connectors, no airframe tie wrapping or concentric twisting, and no epoxied or glue-shrunk connections...Only plastic connectors and crosslinked polyethylene GXL and TXL multi-strand copper wiring without any silver, tin or nickel plating. Guess what, they work just fine...amid increasing complexity, for years on end. A typical mid-sized car will have about 45-70 lbs of wiring. One time we scrapped out a 20 year old Honda Civic Wagon and were amazed at how all the wiring was still in perfect shape...Connector seals were still sealed and clean inside and all the grime, water and heat had not caused any failures. Wiring was still flexible and not cracked. OEM specifications and engineering are pretty damn good. People who say this is inferior are full of shit. This takes sophisticated automated and very expensive machinery and dedicated tooling to pump out six-sigma quality. In short, automotive grade wiring and connectors have a pretty good track record. Not glamorous, but in business, economics and bean counters it seldom is. Aerospace Wiring Airbus 380: With 530Km of wires, cables and wiring harnesses weave their way throughout the airframe. With more than 100,000 wires and 40,300 connectors performing 1,150 separate functions, the Airbus A380 has the most complex electrical system Airbus had ever designed. They got to do it twice i.e. rip it all out and do it over due to incompatibility in various software programs spread across a myriad of suppliers. No concentic twising, no DR-25, no RT-125 epoxy. 20,000 flight hours life. Go figure. You Tube Video. Motorsports Wiring... Race-Spec This has evolved from aircraft and military specifications wherein light weight and reliability are paramount. As motorsports evolved into an increasingly more sophisticated and expensive professional endeavor, specific motorsport connectors have evolved which are even lighter and smaller than their aerospace counterparts. These products don't have to meet oem production testing requirements...They just have to be reliable in a racing environment which is not the same as freezing in Siberia or bouncing down rural roads in your F150 pickup for decades. Sort of serious in a Darth Vader, rubber-fetish way. Bondage and latex in the hell of an engine bay. Above are heat shrink boots sealing circular connectors and the DR-25 heat shrink wire protection. Everything than can slow you down is the enemy....weight of the wires, weight of the connectors and any kind of outright failure, or worse, intermittent failure, which is harder to isolate. This is why F1 might be using tiny 30 gauge wire or why the new McLaren MP4-12C went to extremes in specifying hexagonal aluminum wire to save both space and weight. In motorsport electronics Mil-Spec circular connectors are the norm, full of all sorts of trickery like strain reducing service loops and concentric twisting for flexibility and more compact wiring harnesses. Reliability at 30,000 feet or going airborne at the Nurburgring...it's all the same thing...well, sort of the same thing. Mil-Spec...Race-Spec...Autosport. Service Loops and Service Loop Tools Service Loop Tools allow a loop to be formed, held, and maintained at your wiring harness connector for strain relief and later servicing or repinning. "Service Loops" are used on Mil-Spec / Deutsch Autosport circular connectors for wire sizes 16 AWG to 30 AWG. The purpose is to provide strain relief to the wire termination and to provide a surplus length for repair purposes. It is not an aircraft procedure per se and is only used in military and motorsport applications. Depending on your planning these can go in first or last. The wires have to be loose so doing them as they are installed in the connectors easier with a large number of terminals. In general, it's easier to work from the connector outwards rather than with all the wires bunch up at the connector as shown above...planning all this is a bitch. If you are working outward from the ECU connector, just leave thewires extra long and cut to length, terminate, and finalize length in place forming service loops at the sensor if necessary . PDF on Service Loops. Service Loop Tools and Procedures Motorsport Wiring Service Loop Tools: 6" ChiaoGoo knitting needles come in packs of five. You can get free shipping and -10% for orders of $30.00. These come in different diameters (2mm to 8mm). Stainless steel with rounded tips. Use these to hold your loops in place. If you want to get tricky, O-Rings sized to grip the needle, can hold them in place so they don't slip out for each row or column. Smaller diameters (2.5mm) for circular connectors and larger diameters (6mm) for rectangular or square connectors. The sizes are laser-etched on each needle. On circular connectors it is recommended to start your loops at the center and work outwards if the numbering system runs clockwise or counterclockwise. For rectangular or circular connectors identified in rows, it is recommended to work row by row. Loops should face inwards. Loops must be staggered to minimize any increase in the cable diameter. When looping is complete all loops should face inwards to give a neat appearance and to insure that the wires are not trapped or damaged if an adapter or back fitting is present. If your connector is already terminated and the wires are shrunk with DR-25 it gets a little more difficult as you will have to press back the connector to bow the wires. You may have to cut back on the harness DR-25 to free up the wires. All of this is a bit stiff to wrestle with so holding the wiring harness, the connector, and the looping tool at the same time is a bit interesting. Think ahead. A specialized connector fixture (best) or a vise with aluminum jaws can be used to hold the connector. It is a good idea to wrap an Autosport Connector in Kapton tapes to prevent it being scratched. The connector above features concentric (twist) wiring, service (strain relief) loops at the connector, lacing cord and Kynar clear shrink to hold the wires tightly together near the connector. Kapton tape will cover the wires and service loops at the connector to protect them from the specialized boots (shapes) and RT125 harness epoxy. The DR25 can be terminated with a short length of Raychem SCL adhesive lined heat shrink. With the wires covered by DR-25, the SCL, Kapton tape, and the RT125 sealed boot, the harness will be protected from the environment and from abrasion. Here flat braided lacing tape is counter-wound to hold the concentric twisted wires in place. Something to think about: Were the service loops put in first or last? Generally first and work outwards. Guideline for concentric twisting. Here a Deutsch Autosport connector has its Spec 55 wires wrapped in Kapton tape to prevent the adhesive shrink or harness epoxy from grabbing the wires. The tape allows repairs to be made at a later date. Once the adhesive or epoxy sets it really grabs the connector, the DR-25 wire covering, and anything underneath it. Raychem boots are heat shrunk at about 480F (280C). You use special tips on your heat gun to focus the shrinking of these boots. You can't shrink the boot all at once.Generally you focus on the center and then the ends. By shrinking the mid point you can "cup" the boot and insert the Resintech RT125 epoxy and then shrink that end first...Then finish the other end...Wiping both ends with an alcohol wipe and foam tipped swabs as you go. There is a video of this using TE Connectivity S1125 epoxy further down the page that shows the steps in this process. Low Static Kapton adhesive tape is commonly available in 1/4, 3/8" and 1/2" rolls. The silicone adhesive does not leave any residue. It is amber in color. It is also used to protect circular Deutsch Autosport Connectors during the harness assembly process. Motorsports Wiring...Race-Spec Circular connectors, glue shrunk boots, Raychem DR-25 shrunk over concentric wound silver-plated Raychem Spec 55 XLETFE wiring and, of course, the requisite yellow shrink tube labels covered in Raychem RT-375 clear shrink tubing. Cosworth Pectel SQ6M ECU. Mil-Spec evolved into Race-Spec. Wicked Wicking In case you doubt the need for epoxy or adhesive-lined terminations, the above picture gives graphic evidence of corrosion traveling down the voids between the strands of copper wires. Since we go to the Bonneville Salt Flats two to three times a year for up to a month, and everything gets bathed in salt, properly sealing the electrical connections is a major concern. Year one OK...year two fix one or two things...year three redo everything. Using adhesive-lined or epoxy-based sealing schemes we can keep corrosion out of our wiring harnesses. OEM harnesses employ silicone seals on thermoplastic connectors to address these issues. Any gap in the harness can provide a path to internal corrosion. Sealing With Epoxy Sealing boots and shapes that do not have adhesive melt can be done with specialized two part epoxies. Abrading the inner surface and applying the epoxy to the connector and cable before the heat shrinking operation. Epoxy is not applied to the inside of the heat shrink. Here the connector is sealed to the cable using V25 Deray thin wall shrink tube (2:1) and sealed with epoxy. Resintech RT125 Epoxy The preferred epoxy for sealing wiring harnesses is Resintech RT125. It is a two part semi-flexible epoxy that is mixed 50/50. You can purchase RT125 and a 3M applicator mixing gun from Prowire. These are standard 50ml cartridges. Note they have a shelf life. If you are using this in concert with non-adhesive lined boots do not fill the boot up with epoxy or you will have a real mess. Only seal the ends one at a time. Be prepared to do some clean up wiping with a clean cloth and alcohol as the epoxy hardens much later than the adhesive lined boots. If the entries and exits of the boot are single round diameters then either adhesive lined or non-adhesive lined boots can be used. If non-adhesive then seal the exits with RT125, one exit at a time, wiping the excess off. Syringes are used for more delicate sealing of smaller parts. Here we have sealed the multiple branches under the Raychem boot with Resintech RT125 and shrunk the boot over the epoxy. It's a good idea to use an additional tie wrap strain relief at the multiple branch point. Resintech RT125 3M Mixing Gun 3M EX-PLUS-II-APPLICATOR for the Resintech RT125. This makes the application of the epoxy a lot less messy. About $38.00 from Prowire USA... well spent. You throw away the mixing nozzles after each application as the RT125 starts setting rather quickly. You should let the applied boot and RT125 harden as it can get a bit messy before you go off to the next sealing point. Hanging the harness up so the RT-125 doesn't flow "down" away from the joint is a good idea. We buy the mixing nozzles in packs of 12 as we use RT125 for other projects in addition to sealing wiring harnesses. Epoxy Syringes 3cc and Epoxy Needles 15 ga Sold it kits with supporting materials S1125 adhesive is used to seal DR-25 and Raychem Boots in the same manner as Resintech RT125. This video shows the proper procedure for sealing and testing the bond on DR-25 and molded boots. S1125 is more expensive than RT125. The procedures are the same for both. Here a non-adhesive lined boot is sealed on both ends. With Ideal 46-204 Elite Plus Heat Gun use 46-955 Ovelap Adaptor to shrink the boot. The Raychem Boots are the last items to seal and shrink in the harness. Inexpensive 70% isopropyl prep pads to wipe the overflow of the harness epoxy from the end of the Raychem boot. Motorsport Wiring Vises The Panavise 350 Motorsort WiringVise can be used to hold objects from ecus to bare wire by just flipping the rubber lined jaws around. In general, if you are doing concentric twisting, you need to hold the harness at both ends to do successive layers. Holding the harness at both ends allows you to twist exiting leads. The Panavise 350 is widely used in motorsport wiring and is firmly attached to a production wiring bench. The small circular tray around the base can prove useful holding pins and sockets. Having a lip around your production bench keeps parts from taking a dive. Looking for a 22ga socket on the floor and then rolling your chair over it or stepping on it s not a recommended exercise routine. Inexpensive vises for holding motorsport wiring harnesses and connectors. The SE 8436MVC 3" Universal Table Vise on the left above has slip on soft rubber pleated jaws. The vacuum base Panavise Model 381 on the right we modified with two 4" x 1" x .25" steel plates replacing the Panavise plasic jaws and added a set of 4" NO-M.A.R PlastiXrevolution magnetic polymer magnetic jaws. This gives us a 1/2" to 1"diameter grip on wiring harnesses. Here we are holding an Autosport AS16 26 position connector for socket insertion and service loop forming. Any circular connector clamping diameter beyond 1" and up to 1.250" you will have to fabricate a new lead screw with a 7/16" x 14 x 5" socket head cap screw and drill / insert a 1/4" handle. Use the 350 Vise for larger widths. In gereral, you should wrap Kapton tape around circular Autosport Connectors to keep from scratching the anodized surface. Both vises come with soft jaws. Invaluable when holding harnesses for concentric twisting, forming service loops, or pin/ socket insertion. Available from many sources. The SE8436MVC can mount to the table's edge and the Panavise can be moved around and fixed in place if the surface is non-porous. These are not heavy duty items. Holding wiring harnesses is certainly light duty. We use all three shown. Daniels Mfg has a $750.00 vise for circular connector assembly. Foam Swabs Chemtronics Coventry Sealed Foam 48040 Swabs are perfect for dealing with harness epoxy as you don't have to mess with the fuzzies in common cotton swabs. Available in packs of 500 for about $0.12 each. We use all sorts of potting compounds beyond the harness specific RT125 and have found these to be the best way to clean and manipulate the goo. Raychem Boots The comprehensive guide is Raychem Heat Shrink Products. However, it can get a bit confusing and, in general, you will be using System 25 Specifications for your wiring and connector sealing. For example on a Pectel SQ6M with three Autosport connectors we might use a 90 Degree Boot with adhesive. 222K152-25/225-0. The /225 refers to the factory applied adhesive, and the "25" is the boot material used in System 25 applications. Whether you use adhesive lined boots or seal them on their ends with RT125 Epoxy you use about 480F or 280C with your heat gun with a flat bladed tip. There is a newer "25L" designation for a lighter boot, not listed in the literature. With Ideal 46-204 Elite Plus Heat Gun use 46-955 Overlap Adaptor to shrink the boots. Micro Molded Boots Instalite Molded Boots The Raychem boots on Deutsch DTM06_xS_E007 Connectors. To provide additional sealing and strain relief, either Raychem molded shapes (boots), or adhesive heat shrink like ATUM (3-1 or 4-1 shrink ratios) can be used on Deutsch DTM Connectors. The lip diagonal dimensions above allow you to decide on the proper sealing boot or shrink tubing. Raychem Boots v. Heat Shrink: A Reality Check Electron Speed is a full service motorsports electronics firm. Here they compared, in a controlled test, what happens when heat is applied to the various schemes for connector sealing. It's pretty obvious that dedicated Raychem Boots, albeit expensive, are the preferred solution when paired with harness epoxy (RT125). ATUM (not shown), which is frequently used on DTM Connectors, will react similarly to SCL. HTAT shrink has been discontinued. Keep in mind that Plastic does not corrode. Autosport aluminum connectors will...We know because we spent years going to Bonneville where the salt and salt air eats everything. Deutsch D369 Connectors (3 / 6 / 9 position) have the highest temperature rating of any plastic connector with PEI/PEEK construction and flurosilicone seals...and they are tiny (26-22 / 24-20ga). Get your Raychem Boots at Prowireusa Plastic Coated Twist Ties for board layout motorsport harness assembly Motorsport Harness Layout Assembly: Don't use plastic cable ties when laying out your wiring harness on your workspace, as you will have to continually cut them off and you end up with a bunch of wasted ties and run the risk nicking the harness wires. 1000 twist ties for about $16.00. Use plastic-coated, solid wire, twist ties to holds together temporarily. The coating won't harm any wiring and the wire can be reused. 8" lengths. When laying out your harness on a table or board use 4 way adhesive mounts to locate the harness and leads in place and use the twist ties to hold the wires. It's easy to remove and to add, or subtract wires, for concentric or sensor lead twisting. No wasted plastic ties or nicked wires. 20 Gauge Plastic Coated Wire Spool When you need to hold wire bundle leads together, typically near a multi-pin ecu connector, use plastic coated solid 20 Gauge wire. Buy a roll and snip off a piece. This saves wasting cable ties. No chance of nicking the wires. This wire is too fat to slip into the 4-way adhesive mounts linked above. Cable Ties We have found the best Cable ties are Thomas & Betts Ty-Raps with a stainless steel locking mechanism. Metal locking tabs are a NASA requirement (NASA-STD-8739.4 [7.3.4]) An alternative is the Panduit Contour-Ty (right picture). Normally you use Black Nylon cable ties...be sure they are UV Stabilized and only purchase Brand Names like Panduit, Thomas & Betts Ty-Rap, or Hellerman Tyton. Once at Bonneville we bought some cable ties from local auto parts store and they broke when you tightened them Peek Cable Ties PEEK Cable ties are rated up to about 500 Deg F... way, way, beyond normal Nylon cable ties (185 Deg F). There are priced in the $1.00 each price range for 100 6" ties. Available from Panduit in 4.0" (PLT1M-C71); 5.9" (PLT1.5M-C71); and 7.4" (PLT2S-C71) lengths. MIL-W-22759/32-35 and MIL-W-22759/41-46 or Raychem "Spec 55"Primary Wire (Race-Spec) Raychem Spec 55 wire has become the defacto standard for motorsports wiring. "Spec 55" is a trademark of Tyco Electronics. The actual designation is MIL-W-22759/32-35 and 41-44. MIL-W-22759/44 is the normal wire of choice with silver plated copper stands. Silver plated copper (SPC) strands have a higher temperature rating than does Tinned copper (TC) strands. Spec 55 Single Wall or "interconnect" wire carries the designation 55A011-xx-xx. Spec 55 Dual Wall or "airframe" wire carries the designation 55A081-xx-xx. "XLETFE" insulation refers to Cross Linked ETFE Polymer (Tefzel) which provides increases abrasion resistance over Tefzel insulation. Dual wall construction is commonly used in aircraft. ETFE is described as a "modified radiation cross-linked polymer". Specification Insulation Conductor AWG Range Temp Voltage Wall Type/Thickness M27500 Symbol MIL-W-22759/32 XLETFE TC 30-12 150C 600 Single .006" SB MIL-W-22759/33 XLETFE SPHSCA 30-20 200C 600 Single .006" SC MIL-W-22759/34 XLETFE TC 24-00 150C 600 Double .010" SD MIL-W-22759/35 XLETFE SPHSCA 26-20 200C 600 Double .010" SE MIL-W-22759/41 XLETFE NPC 26-00 200C 600 Double .010" SM MIL-W-22759/42 XLETFE NPHSCA 26-20 200C 600 Double .010" SN MIL-W-22759/43 XLETFE SPC 26-00 200C 600 Double .010" SP MIL-W-22759/44 XLETFE SPC 28-12 200C 600 Single .006" SR Dual wall (normal weight) "Spec 55" will have an inner layer of a contrasting color (blue) to indicate when the wire has been nicked, abraded or cut. TC refers to Tin Plated Copper. SPHSCA refers to Silver Plated High Strength Copper Alloy. NPC refers to Nickel Plated Copper. NPHSCA refers to Nickel Plated High Strength Copper Alloy. Note: 24-30 AWG should use SPHSCA conductor Nickel has a higher melting point than does silver but this is of little consequence in motorsports ecu wiring. Alternatives to MIL-W-22759/44 "Spec 55" Race- Spec Primary Wire A less expensive and more commonly available wiring is the single wall Tin Plated (TC) Copper strand wiring MIL-W-22759/16 or the thinner wall 22759/32. It could be argued that silver has a better conductivity and higher temperature rating than tin plating...but, both offer increased protection against corrosion over bare copper wires. Specification Insulation Conductor AWG Range Temp Voltage Wall M27500 Symbol MIL-W-22759/16 TEFZEL TC 24-00 150C 600 .011" TE MIL-W-22759/32 XLETFE TC 30-12 150C 600 .006" SC The main benefit of Spec 55, MIL-W-22759/44 and MIL-W-22759/32, over the alternative MIL-W-22759/16 is that it is "tougher" i.e. it has better abrasion properties due to its irradiated jacket. This is less of a concern if the harness is sheathed in DR-25 heat shrink, which is a common motorsports practice. In short it is an acceptable alternative to the more expensive 22759/44 silver plated wire. In 20 AWG it weighs 5.18 lbs/1000 feet as opposed to Spec 55 20 AWG which weighs 4.3 lbs/1000 feet. It is also larger in diameter in 20 AWG .060" versus .050" for the Spec 55 wire. A thinner and bit tougher insulation alternative to the /44 wire is the MIL-W-22759/32 and saves a few thousandths in diameter and weight...It's the same price as the /16 wire. Both are tin plated copper ("TC"). Available from ProwireUSA. A thinner tougher wire in the 22759/44 and 22759/32 variations. Wire is really the cheapest part of the equation. It's the labor stupid. We use the /32wire for our harnesses. : When you stock up on 22/20/18/16 gauge wires be careful to keep the various gauges physically separated as it's easy to grab, say, some 20ga (22759/32-20-xx) wire when you really are installing 22ga (22759/32-22-xx) wire. This mistake makes it interesting when you go to install the terminals. Note: Tefzel is Ethylene-Tetrafluoroethylene (ETFE) Dimensions 22759/32- Wire Wire dimensions for both the conductor and the insulation must be known when you are choosing the terminal and seal for a particular connector. Often you will order a connector and seal only to find the terminal is the wrong size for the wire and insulation and or the seal supplied with the connector does not seal the wire. The conductor is expressed in mm2 and the wire insulation diameter is expressed in mm. Metri-Pack 280 Series Injector / Sensor connector example above. 22759/32 Wire Harness Diameter Calculator The above link allows you to determine the harness diameters for 22759/32 wiring. When planning your harness you need to know the diameter of each branch to plan for your transitions and Raychem Molded Boots. The Wire Harness Diameter Calculator takes inputs for 24 to 14 gauge MIL-W-22759/32 wires to determine the bundle diameter. Amperage Ratings Mil-Spec 22759/16/32 Wire The above chart gives a general amperage rating for the mil-spec 22759/16 and 22759/32 wires. In reality, it gets a little more complicated than this as wires have resistance and the longer they are the less capacity they have, and the greater the voltage drop. In a motorsports wiring harness the wires will be enclosed in DR25, twisted together, and not in free air, so there will be more heat, which further degrades their capacity. The chart is based on maximum length to maintain a 5% VDc drop. For a more complete explanation on temperature rise in harnesses view this pdf. In automotive use with longer runs here are safe recommendations: Battery Positive Direct 10AWG Battery Negative Direct 10AWG Other Battery Positive 14AWG Fuel Pump Positive 14AWG Radiator Fan 14AWG Switched Ingition 20AWG 12V 5A Fused 20AWG Tach Output 20AWG Sensors 20 AWG Injectors 20AWG For motorcycle use where the runs are very short we use 14/18/16/20/22AWG To see what the effects of length have on your wire AWG choice visit this calculator which gives you your end voltages and maximum lengths. We suggest you use the 2% drop figure mentioned in choosing your wire sizes. Prowire USA Custom Mil-Spec 22759 Wire Striping In case you wondered how mil-spec wires are color coded with up to 100 combinations of base colors and stripes here's a link to Prowire USA's mil-spec wire striping machine in action which can print up to three stripes simultaneously as well as alpha/numeric, hash marking, band marking, longitude striping and dotting. Complex expensive puppy. Identifying wires in your harness is easier with colors and stripes. Spec55 Wire color codes. There are ten basic wire colors. Add the stripes and there are 100 combinations. If you wish to get your wires organized by numbers (1-12) , and not by colors, Prowire offers a White Wire numbering service...say 1-6 for Fly By Wire etc. Bi-directional. Prowire USA Mil-Spec Wire Modular Rack System (Note: Not Currently Available due to COVID Price Increases) How do you organize multiple spools of wire and Raychem DR-25? Well, not like in the picture above. There are all sorts of wiring spool racks available, but none were created exactly for Motorsports Mil-Spec 22759/16 and 22759/32 wires and also Raychem DR-25 Heat Shrink use. Race-Spec modular rack system for Motorsports. ProWire USA Mil-Spec Modular Rack System: Sneak peak of a new product recently released and available for sale. Stackable modular racking system for Mil-Spec wire, cable and DR-25 heat shrink. Available in different color options as well a raw so you can paint yourself. Shown here is the powder coated blue option. This rack, as shown, will hold 55 spools of Mil-Spec wire as well as 6 large spools of DR-25 tubing. ProWire has several new variations of these racks. All 3 cabinets bolted together are about 70" tall by 28" wide and 24" deep on the tubing cabinet. This cabinet assembly would be $749.99 for all 3 pieces. This rack will hold full rolls of 1/2" to 3/4" tubing on the bottom section (19" diameter rolls). The Middle and top sections are stackable. On those Prowire has: 2 row (20 spool) and 3 row (30 Spools) cabinets available. The unit, as pictured, stands 70 1/4" tall and is 28 1/4" wide and weighs in at 112 lbs bare. This is the best way to keep your sanity and reduce clutter. Go vertical and save time and space. Time is money. These are currently not available due to COVID price increases. Cutting Mil-Spec 22759/16/32 Wire...Rennsteig and Ideal Cutters If you've cut thousands of wires with regular blade type cutters from Ideal, Snap-On, and others you know there must be a better way so the twisted strands stay round instead of being flattened or mushed out a bit. The answer for a perfect round cut is the Rennsteig 8000 1001 3 RT Miniature wire cutter and strand trimming tool (Flush Cut). It cuts wires from AWG 26 to 16 according to aerospace standard AS6173/1. It is not spring loaded to open so you use your finger next to your pinkie to open it. Be careful with these as the cutting edge is easily damaged if you get a bit overzealous, don't get the wire in the slot, or cut the wrong type wire...like thicker GXL or TXL. You have to align the wire each time so this takes time as opposed to usual diagonal cutters.Its major advantage is it leaves the 19 strands of the 22759/16 and 22759/32 wires round. Very clean Another choice is the spring loaded Ideal 45-260 ESD safe knife blade cutter. You don't have to line up the wire in the slot as it is a knife blade. High quality diagonal cutters are available from Knipex . Polished and laser-hardened steel. Everthing from Knipex is A-1. Twisted Pairs: Protection From EMI Interference How do you strip shielded cable for a solder sleeve?...Well there's always a tool. The Ideal 45-402 Ringer Cable Stripper. Crankshaft sensors, camshaft sensors, RS 232 and other communications should use twisted pair, shielded, wiring. 20 or 22 AWG is typical for twisted pair sensor and communications. We use 22 gauge Shielded Tefzel Cable wires from Prowire USA for our two wire crank position sensors and three wire hall-effect sensors. Twisting the wires reduces magnetically induced interference. Forcing the wires together reduces the loop area and therefore the induced voltage. Since the currents are flowing in minimum loop areas, magnetic field generation is reduced. Good idea to avoid signal problems due to noisy ignitions, coils etc. Note that the commonly used model 45-402 comes with a blade and is used on 20-24AWG M27500 SB cable. Grounding of the shielded cable is accomplished by using dedicated solder splices. Section 8-3 of Tyco Electronics (te.com) main Wire and Cable 27.9Mb Catalog lists these solder splices. They are available with or without leads. We ground our shielded wire jackets directly at the SQ6M ecu. Procedures are defined for grounding the of the shielded wires. Best practice is that you leave the shield open at the sensor side for shielding to be effective. If this side is grounded in some way, the shield doesn't work. Shielded gounds are tied to a single ground point at the ECU side. Solder Sleeves are available from ProwireUSA Video: Installing Solder Sleeves Where to Buy Motorsport Wiring Supplies An excellent source for your motorsport wiring supplies for you go-it-alone types is ProwireUSA as they stock about everything you need and sell in small quantities. It a good place to pick up your MIL-W-22759/32 and MIL-W-22759/16 wire and supplies. They have 140 Mil-Spec wire color combinations in stock and even custom stripes and numbers wires to order. ProwireUSA has extensive experience building wiring harnesses and only stocks the best and competition proven parts. Quick service and excellent prices. Don't make the mistake of using less quality supplies from autopart and general supply houses. Prowire also stocks oem TXL and GXL wires as well as the mil-spec 22759 Tefzel wires. Follow Prowire on Instagram. ProwireUSA 22230 S Scotland Court, Queen Creek, AZ 85142 Phone: 619-440-9473 Email: sales@prowireusa.com Connectors Deutsch Autosport: Specifically designed for motorsport. Lightweight. Expensive. Requires Mil-Spec crimping and stripping tools. This is Cosworth Pectel SQ6M that we use on our ORCA motor turbocharged Harleys. The color bands denote the connector shell keyway. The left and right connectors are 26 Pin 20 gauge of different keyway locations so you cannot mix them up. The center connector is a 55 pin 22 gauge connector. Figure on spending about $400.00 for the associated connectors, sockets, and insertion tools for the SQ6M. 107 pins total. Metal shells don't melt like plastic ones do. Higher end motorsport applications all use Autosport ECU connectors...Pectel, McLaren, Magnetti-Marelli, and Bosch. We model the SQ6M with the Autosport connectors to use in our wiring diagrams. One simple way to do layout planning for wire and heat shrink lengths, where the harness makes some turns, is to use electrical wire that can be bent into shape. Here we are figuring out the lengths where the three SQ6M connectors will exit the three 222K-152-25-0 boots and go to the next boot, a Raychem 202A153-25-0. 8AWG works well. Here we used some 4AWG. It worked out to 16", 19" and 22". From there we subtract the overlap from the boots to get the DR-25 lengths. We fudge wire lengths on either end to allow for concentric twisting. We model the various Deutsch Autosport connectors that we use in our harnesses. Pricey devils, but they don't melt, and use Raychem lipped boots sealed with Resintech RT125. Pectel MQ12 controller. Same as used by Aston Martin, Lotus, Nissan Nismo GTR and in World Superbike. Full Autosport Connectors. In case you are wondering how fast this controller can process things it has a MPC5200 processor that delivers 760 Million MIPS (Instructions per second) to keep track of all your inputs. Four Autosport Connectors. What's Between Autosport and DTM Connectors?...Deutsch 369 Series Connectors Deutsch 369 Series Connectors come in 3, 6 or 9 pin variations. These are rated at 175 Celsius (347F) or about 50 degrees Celsius higher than Deutsch DT or DTM Connectors. They are also IP67 rated. Made of high temperature PEI/PEEK materials with Flurosilicone seals, they are about 5 times more expensive than DTM connectors. Designed for aerospace they use #22 Contacts 26-22 AWG and #20 Contacts 24-20 AWG. Rated at 500 mating cycles. Just the ticket for motorsports wiring with its high heat, weight, space, and harsh environment requirements. Less expensive than Deutsch Autosport anodized metal variations. Where exposure and corrosion is an issue PEI/PEEK can offer an advantage over anodized aluminum. We had Autosport aluminum connectors corrode at the Bonneville Salt Flats. This video explains the 369 Connector features The 369 Series are really small parts. Above left is an oversize model of the Deutsch three pin 369 Receptacle. Above right is an actual size model of the 3 pin Receptacle. The actual part is .389" Width by .752" Length...Smaller than a comparable Autosport Connector. Nice items for motorsports wiring with FBW (6 wire) and other sensors which use 22 Gauge wires where heat, space, and packaging issues are at a premium. Pins / Sockets for these are in two sizes: 22 (26-22 AWG) and 20 (24-20 AWG). We use these in conjunction with Black DTM connectors, with the DTM connectors being used with larger 20/18/16 gauge wires. Where to Buy Deutsch Connectors & Mating DT/DTM Raychem Boots Deutsch DT, DTM and DTP Sealed thermoplastic connectors are the cost effective motorsport standard...A step above the ubiquitous Weatherpack connectors.Used by all motorsport wiring professionals in Mil-Spec and Race-Spec Motorsport wiring. The best place to buy these is the Deutsch Connector Store. With 100 rated mating cycles and precise pins and sockets these are the next step below the all metal Autosport Connectors which are way, way, more expensive. Its best to buy these from someone who can provide a complete solution in both parts and tooling. Fast shipment and excellent prices. One thing you might consider as these will not corrode as can happen with the more expensive Autosport Connectors. Connectors and the Rayhem Boots are available for purchase from Prowire USA. Using the Raychem boots is the cleanest most durable method of sealing DT/DTM Connectors. Raychem ATUM works well with its high shrink ratio but will degrade faster under high heat conditions. Using the proper boot and sealing it with RT125 is the preferred solution. Things stay sealed and no seeping adhesive from overheating the ATUM in fabrication or use. Rock solid. If you get confused by all the Deutsch Suffixes in the part numbering scheme check out this page done by LADD. Deutsch DTM Deutsch DTM Series : Sealed thermoplastic connectors designed for harsh environments like engine compartments. Reasonably priced. Available from many sources, they offer watertight silicone seals that also act as a strain relief. Available in 2, 3, 4, 6, 8 and 12 pin contacts with size 20 contacts for AWG 16 to 24 gage wire. Either solid pins and sockets or crimped pins and sockets can be used. Solid pins are crimped and are easiest to work with. In no case should the pins and sockets be soldered. Multiple wire size #20 contacts with 7.5A rating. Pictured above are 2, 3,and 4 pin DTM connectors with the optional shrink boot adapter (Option E007). There are all sorts of suffixes for the DTM connectors and whereas you might spec out a particular option i.e. like the shrink boot...It may not be available in plug and receptacles. We suggest you check out this interactive product guide first. .DXF Files Deutsch DTM Connectors For our CAD wiring harness drawings we construct .dxf models of these Gray Deutsch DTM Connectors on a 1:1 scale. There are downloadable in Autocad R14 .dxf file formats. In Firefox Browser Choose "File, Save Page As", and open in your CAD program. They can be colored as is the gray two pin DTM above. Alternatively you can import .dxf files into Microsoft Visio Professional 2013 using Autodesk TrueView. 2 pin DTM04-2P-E003 2 socket DTM06-2S-E007 3 pin DTM04-3P-E003 3 socket DTM06-3S-E007 4 pin DTM04-4P-E003 4 socket DTM06-4S-E007 6 pin DTM04-6P-E003 6 socket DTM06-6S-E007 All of the pins and sockets are made from 98% pure copper and then plated. Standard plating is Nickel. For critical circuits, pins and sockets are plated with Nickel and then Gold. For lighting, power and control circuits choose Nickel. For critical and very low voltage and amperage circuits such as oxygen sensors that operate at 0-1 volt or 0-5V (wideband) and for data transmission circuits that operate at 5 volts, choose Gold. Type K Thermocouple wire should use Chromel or Alumel terminals (see below) in the DTM two or three wire connectors. Note: rear silicone seal will seal on smooth insulation from .053" to .120" O.D. Of importance is the fact they are rated at 100 cycles of engagement and disengagement. These are your affordable step below the very expensive Deutsch Autosport line. They will melt if they touch something like an exhaust so be careful about securing things before you start an engine. Amphenol-Sine ATM Connectors: Same as DTM Motorsport Alumel and Chromel Thermocouple Terminals: Deutsch DTM Connectors (#20) an Autosport (#22) Amphenol-Sine has come out with a complex array of ATM Connectors that are DTM compatible size 20 connectors. In some cases they may provide boot and color options not available in Deutsch DTM supply chains. For instance DTM 3 way Black Plug and Receptacles do not come with Raychem boot lips...ATM connectors do...Pictured above. ATM06-3S-SR01BK; ATM04-3P-SR01BK Prowireusa Motorsport Thermocouple Terminals Prowireusa has the specialzed pins and sockets in Chromel (+) and Alumel (-) in sizes 20 and 22. These are crimped with the Crimp Tool M225201-01 (DTM) and MS22520/2-01 Crimp Tool (Autosport) and the appropriate K41(M22520-06) and K42 (M22520-09) positioners, "MS" Contacts have a BIN (Basic Identification Number) code consisting of three color bands around the crimp barrel. There are 10 colors which designate a number. The BIN codes are read from the wire barrel end of the contact towards the mating end. The first band is wider than the other two to further facilitate identification. Bin-code can also be stamped on the contact. Example: Red/Yellow/Black above would be -240 suffix. Deutsch DTM #20 terminals in Alumel and Chromel are available. The sequence of the color bands defines the terminals material and type. 0 = Black 1 = Brown 2 = Red 3 = Orange 4 = Yellow 5 = Green 6 = Blue 7 = Violet 8 = Gray 9 = White Thermocouples, either EGT probes or Cylinder head temperature, have to be wired with special thermocouple wire all the way to the ECU input pins. You must use Alumel (-) or Chromel (+) wires and terminals i.e. pins or sockets, or you will have cold-junction errors. The all-metal Deutsch Autosport Connectors have specialized size #22 Alumel and Chromel terminals as well as #23 for the MicroLite Series. There are also size #20 Chromel and Alumel Terminals available for the less expensive DTM series of connectors. Pectel SQ6M ECUs have two dedicated EGT Chromel (+) pins: (TC1 POS [YEL Wire], TC2 POS [YEL Wire]); and one common EGT Alumel (-) pin (TC NEG [RED Wire]) in the AS216-35PN connector. Chromel Pins Size #20: MIL-C-39029/9-135; Brown Orange Green Alumel Pins Size #20: MIL-C-39029/9-134; Brown Orange Yellow Chromel Sockets Size #20: MIL-C-39029/10-141; Brown Yellow Brown Alumel Sockets Size #20: MIL-C-39029/10-140; Brown Yellow Black Wiring thermocouples into a motorsport harness is a bit different than industrial applications as we typically use a a three position plug / receptacle connection in a branch off the harness. If the thermocouple is shielded then one terminal of the three position connector should connect the shield/drain from the main harness to the thermocouple. You never ground the drain wires at the thermocouple but back at the ECU, typically at the ECU's chassis ground splice. Pectel SQ6M ECUs have two dedicated Chromel thermocopule positive pins and a common (spliced) thermocouple Alumel negative pin. You should always use Alumel and Chromel thermocouple extension wires in your harness. Stranded wires offer flexibility and foil sheathing and a drain wire offer additional protection. Motorsport Thermocouple Harness Wiring Example: Connectors and wire for EGT Type K Thermocouples. Thermocouple ALCOR 86161 90 Deg 1/4" NPT DTM04-3P-E007 with Raychem Boot 202K111-25-0 (abrade DR-25 and RT125 epoxy) DTM06-3S-E007 with Raychem Boot 202K111-25-0 (abrade DR-25 and RT125 epoxy) Chromel Pins: Prowire 710106 Alumel Pins: Prowire 710104 Chromel Sockets: Prowire 710103 Alumel Sockets: Prowire 717102 Drain Pins: 0460-202-2031 Drain Sockets: 0462-201-2031 (3) Solder Sleeves (drain wires): Prowire S01-03-R; use 22ga drain wire BLK CTC-0018-24-9/5-9 (19 strand): Twisted Pair: Green Chromel(+); White Alumel(-); Jacket White Strip CTC-0018 with Ideal 45-402 Ringer Cable Stripper. DR-25 covering thermocouple wires and harness wires. Motorsport Thermocouple Wire 19 strand CTC-018 Raychem Motorsport Alumel Chromel Type K wire. pictured above. This is the best motorsport thermocouple wire, but not easily obtained and expensive. TE Connectivity. About $300.00 for 25 feet of 44 gauge. We use this wire in 24 gauge. Two Thermocouples: Green wires (+) to pins 4 and 11, C2 Pectel SQ6M. Parallel spice White wires (-) to pin 13 C2 SQ6M CTC-0018-24-9/5-9 CTC-0018-22-9/5-9 CTC-0018-20-9/5-9 More common is 24ga stranded (7x32), typically shielded, with a integral drain wire. Various sources. If shielded with a drain wire, use 3 position connector with gold terminals on the drain wire Cover leads with Raychem DR-25 and heat shrink the 3 position DTM connectors for strain relief. Typically is type K Thermocouples. The fastest acting thermocouples are the grounded type with thinner probes. Grounded means there is a continuity between the probe and either of the two wires. The thinner diameter probes are made of Hastaloy-X, or similar high temperature alloy. Depth should be adjustable so the tip of the thermocouple is centered in the exhaust stream. Place 1/8", 1/4" NPT or 1/4 x 20 welded-on mounting points on the upper quadrants, not beneath the exhaust port. Expect 1% accuracy. In the case of single or multiple thermocouples they should be equally spaced approximately 2"- 4" from the exhaust port...The further away, the more of a temperature drop. They should not be placed in a collector. Thermocouples with exposed tips and 1/4" thick, insulated, probes are not as fast acting and are susceptable to damage. See below for how thermocouples actually act. For testing and calibration purposes we use a Thermoworks Microcal 2K that can be set to a particular temperature C/F to .1 degree F and .3 degree C accuracy. A handy Deg C to F and Deg F to C PDF from Omega. Thermocouple Misconceptions Robert Moffat in his Gradient Approach to Thermocouple Thermometry explains that the thermocouple voltage is actually generated by the section of wire that contains the temperature gradient, and not necessarily by the junction. For example, if we have a thermal probe located in a molten metal bath, there will be two regions that are virtually isothermal and one that has a large gradient. In the figure above, the thermocouple junction will not produce any part of the output voltage. The shaded section will be the one producing virtually the entire thermocouple output voltage. If, due to aging or annealing, the output of this thermocouple was found to be drifting, then replacing the thermocouple junction alone would not solve the problem. We would have to replace the entire shaded section, since it is the source of the thermocouple voltage. In short, keep the thermocouple, even fast acting ones, well into the center of the exhaust stream, not just the exposed tip. Designs with this probes and grounded designs are the fastest and most accurate. DTM Terminal Removal The simplest way to remove DTM Terminals (Pins, Sockets) is to: (1) pull out the plastic terminal lock with a small needle nose plier and then, (2) use a small flat-bladed screwdriver...Typically the one you have that has a magnet on the other end, and release the tab lock by pressing down and pull out the wire. Simple. Detusch DTM Black Everyone seems to use only the Gray DTM connectors simply because that's what they see everywhere. The DTM series actually comes in 11 colors. We use the Black DTM connectors on our production street harnesses as they blend in with the DR-25, Raychem Boots, and heat shrink tubing. On motorcycles Black sort of disappears whereas the Gray stands out. We use the E005 End Cap option when it's available...like the "Cat-Spec" DT Series pictured below. .DXF Files Deutsch DTM Connectors For our CAD wiring harness drawings we construct .dxf models of these Black Deutsch DTM Connectors on a 1:1 scale. There are downloadable in Autocad R14 .dxf file formats. In Firefox Browser Choose "File, Save Page As", and open in your CAD program. They can be colored as is the black two pin DTM above or the 12 pin DTM connector below. Alternatively you can import .dxf files into Microsoft Visio Professional 2013 using Autodesk TrueView. 2 pin DTM04-2P-E005 2 socket DTM06-2S-E005 3 pin DTM04-3P-E005 3 socket DTM06-3S-E004 4 pin DTM04-4P-E005 4 socket DTM06-4S-E004 6 pin DTM04-6P-E005 6 socket DTM06-6S-E005 8 pin DTM04-8PB 8 socket DTM06-08S-E007 12 pin DTM04-12PB 12 socket DTM06-12SB-E007 "Cat-Spec" Detusch DT Deutsch DT Series have #16 contacts with a 13A rating. Often called "Cat-spec as they are used by Caterpillar and have improved seal retention on the plug and a cap on the rear of the housing to retain the silicone wire seal. The Deutsch DT-RT1 is a removal pick for the Deutsch DT Series only. The tool has a double ended removal tool. One end has a sturdy 90 degree hook for non-slip wedge lock removal. The other end has a standard flat head screw driver which can be used as a straight pick or driver. Tool has a tapered one, four sided handle. DT-RT1 application instructions PDF. Controller Area Networks (CAN) Specialized DTM Connectors for SAE J1939/15 2-wire CAN systems. DTM04-2P-P007 Receptacle "Y" Connector above left. Right: DTM06-2S-EP10 Plug with molded-in 120 Ohm Resistor. The Valuecan3 is helpful Diagnosing CAN issues. CAN-BUS Joysticks Grayhill's Series 3J Vehicle Display Controller (VDC) is an operator interface device for on-board software. The VDC features an optical rotary encoder for scrolling through menu options and a center pushbutton for selecting options. Five "hot key" pushbuttons are placed around the center shaft to quickly pull up the most common functions. Legends on the hot keys can be chosen from a library of ISO standard legends or customized with new symbols. An optional 8-way joystick provides cursor control for navigating on-screen. CANopen and J1939 protocols are available as standard options. Download VDC Brochure on these. Sureseal Sureseal: Interesting rubber push to connect seals. Like any specific connector they require specific and expensive tooling. These connectors are rated at 50 cycles of engagement and disengagement. We have used them in the past but prefer DT/DTM/D369 and Autosport connectors. Weatherpack Weatherpack: Ubiquitous automotive silicone sealed thermoplastic connectors designed for harsh automotive environments. These connectors are validated to perform to specification for 10 cycles of engagement and disengagement, but up to 50 cycles probably will not see any signal degradation. In short they are excellent for oem use but a bit wanting in a motorsports environment where >10 engagement/disengagement cycles are normal. For over 25 years we used all the one to six pin variants with GXL and TXL wire and they were reliable but not motorsport grade. Weatherpack GM MAP Sensors can be further sealed with a [HellermannTyton (page 63)] shrink boot available from ProwireUSA. If you use GM 1, 2, or 3 Bar Map Sensors with 22 Gauge 22759/16 or /32 wire use the 15324983 DARK RED Silicone Cavity Seals and Pins 12089307 (22ga). Appropriate pins, sockets and seals for the different wire sizes are available from ProwireUSA. GM 2 and 3 Bar Connector 12015384 Black; GM 1 Bar Connector 12020403 Green. Although the Weatherpack connector is "sealed" by the cavity seals it is a good idea to provide additional strain relief. Alternatively seal the ends of the DR-25 with 1.2" of ES2000-1. BOSCH T-MAP Sensors Before you automatically use the three pin GM MAP Sensors you should consider engineering your project for BOSCH T-MAP sensors that have four contacts and combine temperature and manifold pressure in one sensor. You can kiss some pneumatic tubing and tees good-bye. A better way to fly. Cut your sensor count in half and get rid of some problematic vacuum / boost tubing and clamps. 1 Bar: 0261 230 030; 0 261 230 333 2.5 Bar: 0261 230 042 3 Bar: 0281 002 437; 0281 002 845; 0 261 230 280 3.5 Bar: 0 261 002 456 4 Bar: 0 281 002 576 For 22ga 22759/32-22 wire: Connector BOSCH 1928403736; BDK Terminal 1 928 498 056 (20 AWG); Seal BLUE 1928300599 (.35-1.0mm2) Injectors and Connectors The trend in injectors is to use the Bosch EV14 injectors which are high impedance, typically 12 Ohms, instead of the older style Low Impedance (2-3 Ohms) as the EV14's are very fast opening and very accurate. To use these you will need to use USCAR EV6 Type B Red style injector connectors (Green Cavity Seal 22ga). The exception to this are the ID2000 Injectors which use a Sumitomo 6189-039 Injector Connector (Black Cavity Seal 22ga). People tend to yank on the injector wires which are typically 22 ga. Make sure you have the proper crimping tool. Do not solder the wires...ever. Crimp 22 gauge with the Delphi GT150 Connector crimping tool (15359996), after removing the spring loaded plastic GT150 terminal stop, using the 22-20 position. If you are using 20 gauge wires you can use the general purpose Delphi 12014254 Crimping Tool. Bosch EV6/14 Injector Connectors and Seals Connector Left Above: Delphi USCAR EV6/14 Bosch Injector connectors (15497399 or 15419715-B) and secondary lock (15423278 Blue) are often delivered with Green or Blue Delphi Cable Seals. At RB Racing we use 20AWG injector wires and the Green Seals do not seal the 22759/32-20 wire. We use White Delphi Cable Seals 15366021. Delphi Global Terminal 22-20 AWG 12191818. Prowireusa carries genuine Delphi EV6-USCAR6 connectors, terminals and seals...These are easier to use than the commonly sold ones with a red push to lock component (coonector right above). The Genuine Delphi have a secondary (blue) lock that separates the wires and retains the cavity seals. A better solution and you don't have to deal with the red locking component that accidentally can be pushed in. PDF giving Delphi GT150 and GT280 cavity seal dimensions and colors. These days there is a lot of BS floating around about injector matching etc...Take our advice and use Injector Dynamics Injectors as they work directly with Bosch Motorsport. Check out the lengths they go to in this video. We use their 750cc, 850cc, 1000cc, 1050cc, 1300cc, 1700cc and 2000cc injectors. Pictured above are the new ID1700X injectors developed in conjunction with Bosch Motorsport. Tony Palo drives a 2400hp GTR so he's crazy like the rest us...only he has more horsepower. Circuit Breakers not Fuses Passenger cars use fuses everywhere whereas, in motorsports, re-settable aviation-style circuit breakers are preferred. Circuit breakers have the advantage of being re-settable which allows you to perhaps just "push it in" and get going until you diagnose the problem. You also don't need to replace a fuse. Harley uses truck style thermal breakers...your bike would sign off due to some short and a few minutes later it would run again...but you didn't melt your wires. Tyco W23, ETA 483, and Klixon 2TC14 series push to set circuit breakers are a standard aviation item and are available in many amperages. They "pop up" when they trip and you push them down to reset them. If you are using the popular sealed WeatherPack silicone sealed fuse holders you can use Bussmann 227 series circuit breakers that are a drop in replacement, albeit pricey, for the cheaper one time fuses. Klixon 2TC14-X (green breaker) are available from ProwireUSA in varying amperages from 1A to 25A for about $20.00. Higher end ETA 483 series are about four times more expensive. Breakers like the Tyco W23 are usually installed in panels that a race car driver can reach and reset. "Reach and reset" doesn't work on motorcycles. Space is also a premium on motorcycles and there is the issue of being exposed to the elements like pressure washers. If you go to the Bonneville Salt Flats like we do then corrosion is a major issue. A second issue for our applications is high vibration and the three threaded points...possible issues with that. Cooper Bussman 227 Low Profile ATC Blade Type Manual Reset Circuit Breakers pictured above. There are nornally installed in a fuse box in place of the standard ATC duses. These are too tall to fit in Delphi Metri-Pack Sealed Fuse Holders (12033731 Cap Cover and 12033769 Female Connector). Waterproof Fuse/Circuit Breaker and Micro Relay Enclosures For motorsport wiring the Bussmann enclosures present a simple, compact, solution in a waterproof, sealed enclosure. Sealed Busmann Enclosures can house a various combination of 280 series (.320" c-c) Mini Fuses, 280 series mini circuit breakers and ISO 280 Micro Relays. There are a variety of these bussed and non-bussed, so be careful when you order them. IP 66 weather tight sealed. Cheap and compact for $20.00...or use $2000.00 and up programmable PDMs. Mini 280 series (SAE J553) Circuit Breakers can be either auto-reset or manual reset (2 versions). These use Delphi Metri-Pack 280 Series (sealed-tangless) connections on the back side: Metri-Pack 280 silicone cable seals : 15324985 (purple 20-22ga); 15324982 (green 18-16ga GPT; 20-18 SXL); 15324980 (gray 14ga GPT; 16ga SXL); Cavity Seal Green 12010300; Terminals: 12084201-L (22-20ga); 12110847 (18-16ga); 12129409 (16-14ga). All parts are available from Waytek Please note that the mounting screws go in from the fuse side as the inserts are split, self-clinching, and the I.D. is smaller on the "back" side. Part designations are (3) 10-32 or (4) 5mm. Normally these enclosures are inserted through a panel hole with the screws going through the panel and into the fuse side. Typically, with 10-32 threads, we use 18-8 Stainless Steel Pan Head Phillips Screws 10-32 x 1/2" with 16ga thick panels. Should you have a space premium on the "back side" where you wish to mount the Bussmann enclosure on top of a panel cut-out (wires), and put the screws in from the back side, then you can run the appropriate tap (10-32 or 5mm x .8) through the top of the insert so the screw will easily thread into the back side. We use 18-8 Stainless Steel Phillips Screws 10-32 x 1/2" with #10 18-8 Stainless Steel Split Lock Washers on a 16ga panel. In the picture above the Bussmann enclosure is installed on a Harley-Davidson FXR (the side cover needed to be spaced out). Lots going on in small space as space is at a premium with about 80 outboard connections. Pectel SQ6M controller for a turbocharged application. 18-8 Stainless Steel Phillips Screws 10-32 x 1/2" with #10 18-8 Stainless Steel Split Lock Washers coming in from the back side. Panel Mount Circuit Breakers High Amp Series 17 Waterproof Panel Manual Reset Circuit Breakers from Mechanical Products are available from Waytek Inc. Amperage Ratings from 25 to 300 Amps Trip-free operation Industry standard terminations available in panel and surface mount New "Easy Access" Panel Mount and "Side by Side" Surface Mount configurations available Surface Mount available with 1/4" and New 3/8" stainless steel terminal studs and sems nuts Panel Mount available with 1/4" brass, nickel plated terminal studs and stainless steel sems nuts Auto, manual, or manual push-to-trip options Dustproof and waterproof Visible trip indication Ignition Protected Sealing Backs of Circuit Breakers Raychem SCL heat shrink can be used to seal circuit breakers and other types of switches from the environment. Much niftier than trying to heat shrink a couple of screw terminals. It is a dual-wall adhesive lined shrink tube with a 2.5:1 shrink ratio. A greater shrink ratio (4:1) can be accomplished by using Raychem ES2000, or DSG-Canusa CDR adhesive-lined semi-rigid shrink tubing. Raychem ES2000 is available in small quantities (4' sticks) from various electronic suppliers like Mouser. Sealed K4 Toggle Switches K4 Triple Sealed Switches are used in off road racing and other motorsports where moisture and dust are your enemy. Complete K4 Catalog. Available from ProwireUSA. Sealed Toggle Switches with Leads Instead of having to deal with exposed blade contacts or tiny brass screws with eyelets, get a sealed toggle switch with lead wires and install a Deutsch DTM Connector. Grote 82-2111 SPST Toggle pictured above left. Switch is completely sealed in epoxy. Silver contacts for long life. Waterproof and Dustproof to IP68 standard. Similar switches, above right, are also available from Littelfuse. Several less things to worry about...no loosening of screws or issues of sealing blade contacts from corrosion. Here the Grote 82-2111 with a DTM connector, Raychem DR-25, RT125 sealing and ATUM 16/4. Alternatively you can hardwire the switch with two step-down butt connectors (offset them) and seal the connections with 1.2" ES2000-1 and cover with 1/4" DR-25 sealing both ends of the DR-25. P7 Waterproof Pushbuttons From Prowire As we all know being waterproof is better than not. SPDT Momentary. Otto P9 Pushbuttons..Momentary or Latched..Plastic OTTO P9 pushbutton switches. They come in different color buttons with buttons raised or flush and a myriad of options, but you really need to label them where they are installed. These have a 6 to 7 digit ordering number after the "P9" so be careful when you order them. These are plastic construction. 15/32 thread. IP 64 rated. Grayhill 30 Series Pushbuttons...Momentary..Machined Aluminum Grayhill 30 Series Momentary Pushbuttons. These are machined aluminum with a Black Chrome finish. 1/2-32 thread. We use these for page, mode, and shifter buttons. IP67 rated. We also machine a backshell to use a Raychem Boot (224W221-25-0) and seal the assembly with RT125 epoxy. Threads on these are shorter that the Otto P9 pushbuttons. K4 Battery Disconnect Switch K4 Battery Disconnect Switch. If you run expensive Lithium Racing batteries you need to remove any parasitic draw to prevent the battery voltage from dropping when the vehicle sits for awhile. If the voltage drops too low due to long term milliamp draws it can permanently kill the battery unless the battery has circuitry to protect itself. The switch also serves as a safety kill switch where regulations require and manual disconnect. Rotary Map Selection Switches Rotary position switches are a fact of life in Formula 1...Fuel, suspension, traction control, braking bias and whatever the rules allow these days with the spec ecus from McLaren Electronics are all switchable on the carbon fiber steering wheel. We make up our own Rotary Map Switches that have to survive on a Harley-Davidson. We set these up for four map positions. Traction control maps, fuel and spark maps...all changeable on the fly. Four position switch pictured uses three resistors to set voltages from 5 VDC to 0 VDC in equal steps. Here is the final assembled switch with the laser cut stainless steel mounting bracket and faceplate. Laser cut slots allow the faceplate and the mounting bracket to index to each other. We stamp the switch positions into the faceplate. The entire assembly is sealed for reliability. We label the color of the signal wire so it can marry up with the appropriate DTM connector on the wiring harness. We machine the switch enclosure from Delrin plastic and encapsulate the rotary switch in epoxy to waterproof it and use DR-25 heat shrink and formed boots to protect the wiring and install a three position Deutsch DTM connector. 5 VDc, Analog Ground and Signal wires (color coded). We pot the Delrin enclosure / switch with Resintech RT125 on both ends. It takes a few days to cure. Eight Position Traction Control Rotary Switch. Seven resistors set voltages from 0 VDC to 5 VDC in equal steps. Pectel SQ6M controllers have 7 traction control settings. Position #1 will be traction control "Off". Stripping & Crimping Ideal Ergo Elite, pictured on the left, is an excellent wire stripper...Be sure you order the model 55-1987 for MIL-W-22759 wire plus the LB-1904 Clear Plastic Wire Stop. About $250.00. The clear plastic Wire stop cuts accurately but can trap the insulation between the stop and the blades. Often we leave the stop off. The Ideal 45-177 Stripmaster Lite (16-26 AWG, Type E Teflon), on the right, is also an excellent choice. Keep the screws in the jaw tightened as they tend to loosen with use. You should also order the L5720 Wire Stop Assembly. About $150.00 We suggest you get the Ideal Ergo Elite for the most precise work. Wire Stripping Thermal The claim is that thermal wire strippers do not nick or cut or scrape the wiring. There are several manufacturers like Teledyne and Hakko. The Teledyne Strippal® Plus pictured to the left above is a self-contained hand-held stripper that either comes with a fixed or variable temperature control. The insulation melts and is stripped cleanly and quickly, readying the wire for crimping or soldering. To the right is the Hakko FT-801 thermal wire stripper. We don't like getting burned by hot objects. We tried thermal strippers long ago but it was back to mechanical and automatic blade strippers. Best to skip these and use precision blade manual or production automatic strippers. Ideal 950 Stripmaster This is the pricey pneumatic stripper we use at RB Racing. It simplifies doing production work and the stripped insulation collects in the tray. Of course we still use hand strippers because the 950 is best used as a stationary unit, not suited for lugging around the shop doing prototypes in place. It's small but pneumaticall powere so it is best used as a Bench item. Schleuniger UniStrip 2300 If you are doing production work and don't want to spend the day squeezing manual crimpers then you need spend about 25 times more money for an electric stripper like this one. Video of it in action. Used by many wiring professionals. Crimping Tools Daniels crimping tools are the defacto standard for motorsports connector pins and sockets. We also use specialized tools to crimp Weatherpack connectors and Deutsch connectors. Daniels

AFM8 Turrets M22520/2-07 Autosport 22 gauge sockets M22520/2-09 Autosport 22 gauge pins M22520/2-10 Autosport 20 gauge sockets M225034 Autosport micro sockets M225035 Autosport micro pins M22520/2-02 Turret for DTM and Mil Spec Pneumatic Daniels WA22 Crimper In addition to hand crimpers we use a Daniels WA22 pneumatic crimper for consistency and to save time. Mounted on a BM-2A Bench Mount and controlled by a WA10A foot pedal. Makes a nice whooshing sound. Crimping This is a selection of the crimping tools that we use to make our motorcycle harnesses. Daniels, Delphi, AMP, Rennsteig, and Deutsch crimpers. We don't do custom wiring harnesses except for our own products and racing. As an example: We use high temperature nickel-plated ring terminals for applications like fuel pump connectors and motorcycle VBat+ and Vbat- connections. It's very important that these do not fail or corrode. We shrink 1" long Raychem SCL strain relief. This is a 22-16 x 1/4" K.S. nickel-plated ring terminal with a 22759/32-14 AWG wire crimped...It passed the Vise-Grip and bench vise tug of war contest. These are butted, and not brazed, so we "F-crimp" with the crimp on the butted seam. In our documentation we specify the crimp tool used for this operation. Ratcheting Crimper Rennsteig PEW-9 There are different types of crimps used for different purposes i.e. insulated or non-insulated connectors. The Rennsteig PEW-9 shown here with a hexagonal crimp die for non-insulated splice connectors. These are moderately expensive, around $120.00. No interchangeable dies as it is calibrated at the factory. The hexagonal crimp is a superior crimping method for splice connectors. For single splices 18/16/14 ga and for multiple of smaller wires. We use this crimper where the final crimp does not under or over-crimp the splice. We also use AMP crimpers for splices, typically the AWG 22-10 Double Action Tool 49935. Rennsteig MultiCrimp Ratcheting Crimper Rennsteig also has a MultiCrimp tool with interchangeable dies. About $250.00. Fives dies are available. It normally ships with with: - 1x (P/N 629 050 3 0 1) Die Set for Non-Insulated Plug Connectors (0.5 - 6.0 mm^2 | 20 - 10 AWG) - 1x (P/N 629 060 3 0 1) Die Set for Insulated Terminals (0.5 - 6.0 mm^2 | 20 - 10 AWG) - 1x (P/N 629 090 3 0 1) Die Set for End-Sleeves/Ferrules with and without Collar (0.25 - 6.0 | 24 - 10 AWG) - 1x Tool magazine for up to 5 Die Sets Less expensive ratcheting crimpers are available from Del City. Some aerospace items can be up in the thousands of dollars. A good guide to crimping is in the Molex Industrial Crimp Handbook. Page 18 of the Molex PDF describes the types of crimp dies. ProwireUSA Motorsport Battery Cables These are the best battery cables for your racing application. Don't go looking for welding cables, get the correct motorsport ones. ProwireUSA also has the correct lugs. In order to crimp the lugs you can spend anywhere from $35.00 to $3,000.00 for specialized hexagonal crimp tools. If you are only going to do this occasionally a cheap Hydraulic Crimper (read China) with insertable hex dies can be had for under $40.00. Pictured is an 8 ton crimper with 4, 6, 10, 16, 25, 35, 50, and 70mm die sets. Definitely not Aircraft Milspec but cheap. Metric to AWG Conversions: 10mm (6AWG); 16mm (4AWG); 25mm (3AWG); 35mm (2AWG); 50mm (0AWG); 70mm (2/0AWG). Wire to Wire Splices Planning for splices in your wiring harness represents the most complex and critical part of the design process. Careful planning can reduce complexity and increase reliabilty. You need to plan all your spices first as the ecu pin direct to input circuits are easily defined. We typically have about ten or more defined splices for the various circuits. We construct these first with splice points typically within the Raychem boots where wires branch out. Stub (Parallel) Splices can be grouped in your ecu connector boots so individual runs can be run for circuits like 5V sensors. Here we have ten 22ga wires. Step Down butt connectors can also be used but these take up more space so we primarily use Stub (Parallel) splices. ECU's like the Pectel SQ6M have two separate 5V and two separate 12V programmable output channels. These, in turn, can be grouped into parallel stub splices within a harness boots and the individual 5V and 12V outputs can be sent downstream. Splice planning is something that must be done at the start of the design process. Wire to wire splices can be accomplished with Tyco Raychem D-406, or Sumitube W79 adhesive lined shrink tube. Do not solder the wires together. Proper crimping is the preferred method .Raychem part # D-406-0001, Red in color, marked "Duraseal 18-22" pictured. We tend to use the un-insulted butt, step-down and parallel splices (below) and seal them withe Raychem SCL.

Alternatively, un-insulated step down butt connectors (left and center above) can be used and sealed with adhesive-lined Raychem SCL heat shrink. Often wires will branch i.e. 1-2, 1-3, 1-6 etc. and splices are necessary. To the right above is a Raychem Mini-Seal Splice...these have an overall shorter length and can be sealed with SCL or ES2000-1 heat shrink. In general we do not use Butt Connectors as we prefer the conductor to conductor crimp in the shorter Molex parallel splices which can offer better strain relief depending on how they are sealed with Raychem SCL. Number of Wires in a Molex Parallel Splice This calculator will compute the diameter of your conductor wires that can be inserted into a Molex Parallel Splice. We use AMP 49935, AMP 69363 and Rennsteig Hex crimp tools for Prowireusa Molex Parallel Splices. These are usually sealed and pinched off (open end) with a short section of Raychem SCL heat shrink tube. The SCL is very stiff and provides strain relief. The SCL adhesive is black...nice aesthetically. Below is a visual example of the diameters and number of wires that can be placed in these connectors for your planning purposes. When creating splices these parallel splices are the smallest package in your harness i.e the smallest wire to wire crimp, often within a connector boot. Seal with the appropriate size Raychem SCL. Ultrasonic (weld) Splices OEM production harnesses use ultrasonic welding to make splices which are covered with shrink tubing. This is generally for bare copper wires . Slower than automated crimping but results in a smaller harness. Some welders have tinned wire capability. Only increase in diameter is the thickness of the shrink tubing. Sonobond SpliceRite. A video shows how the process works. Splice Testing Here we have two multi-wire splices via step-down un-insulated butt connectors: (below) five 22 gauge 22759/16 black wires going into one black 22 gauge wire; and (above) four 18 gauge 22759/16 red wires going into one 16 gauge 22759/16 wire. The connections are glue shrunk. In the case of multi-wire butt splice connections we use 1/8" adhesive lined shrink tube on the single wire and a larger size (3/16" or 1/4") over the entire splice. We make sample splices, in this case stripping the wires and crimping them in the butt or parallel splice connectors. Do not twist or solder the multiple wires together. All connections must be adhesive sealed, typically with 3/16" or 1/4" Raychem SCL (.750" to 1" on Parallel Splices and 1.5"on Butt Splices). Make assembly notes as to the crimp tool / position to use to avoid assembly errors. For a comprehensive guide to Un-Insulated butt connectors see the TE Connectivity/AMP Solistrand Un-Insulated Terminals and Splices PDF. These go down to 26AWG-20AWG (#321198) pictured above. For these we use AMP Crimp Tool 69363 26-24 22-20. For AWG 22-10 we use AMP Crimp Tool 49935. We don't have pull testing equipment so we simply take the test pieces and yank on the wires as hard as we can. Be careful to insure all wires are fully seated into the butt connector. Refine your crimper choice and crimp techniques until you can be assured your splices will not come apart. Not sophisticated but it works. FYI: NASA-STD 8739.4: Minimum Tensile Strengths: 22ga 13 lb; 20ga 21 lb; 18 ga 32 lb; 16 ga 41 lb. SAE AS7928: Minimum Tensile Strengths: 22ga 15 lb; 20 ga 19 lb; 18 ga 38 lb; 16ga 50 lb. Solistrand (Parallel) Splices in Boot When you are terminating multiple wires in a splice in your harness, and not a wire-to-wire butt splice, Solistrand Stub (Parallel) Splices are called for. Use a Rennsteig Hexagonal crimp tool or an AMP Crimping Tool and then seal the parallel splice with SCL or a Raychem ES Cap. In the above illustration we show a Stub (Parallel) Splice application... Here we have a 5V 50mA output from the #2 Autosport Connector on a Pectel SQ6M sending out 5V sensor power to three destinations. AS6-16-35SN connector with a Raychem 222K152-25-0 boot. The SQ6M has four programmable sensor supply outputs: Two @ 5V 50mA and two @ 12V 1A. Using parallel stub splices simplifies having many butt connector splices downstream. Lots of planning is required for concentric twisting of your harness. Placing the parallel stub splice in the connector boot cleans up things. Raychem ES Caps for Parallel Stub Splicing Wire to Wire Solder Splices Joining wires without crimping in a sealed manner requires the use of specialized solder sleeves that both solder the wires together and adhesive seal them at the same time. Pricey devils. Figure upwards of $3.00+ each. Pictured is Raychem / Tyco D-1744 Series Soldersleeve Wire Splice. Designed to provide an environment resistant in-line splice in wires having tin (22759/16 or 22759/32) or silver-plated conductors (22759/44) and insulation rated for at least 125C. Example pricing via DigiKey. Deutsch Jiffy Single Wire Splices When you want to do a sealed splice on an exposed single wire, that you may wish to take apart, these Deutsch Jiffy Splices will do the trick. These are for larger gauge wires. Pin and Socket Retention Testing Daniels makes a relatively inexpensive tool to test retention of pins and sockets...Simply push until flush and the socket/pin is tested to about 30% of it's yield i.e. if it is actually seated. If you are a big buck operation and you need to test your crimp connection strengths you buy one of these from Alphatron DR-25 Heat Shrink and Molded Parts DR-25 heat shrink and transitions are joined with Raychem or Hellerman molded parts, To seal the ends of the transitions or boots there are two options: Use adhesive lined boots (expensive) or use syringe-applied Resintech RT125 black epoxy on the connector or the DR-25 wire cover. The shrink ratio is 2-1. This environmentally seals the wires and connectors and provides a protective layer against abrasion. Raychem DR25 is simply the best wire covering. The suffix determines the color of the printing on the tubing DR-25-1/8-0 is Yellow; while DR-25-1/8-UK is White lettering. Color of the lettering is simply customer preference as the DR25 is exactly the same. We use DR-25 in the standard thickness with the yellow print as it seems a bit sexier and is visually diffrent than other suppliers being instantly recognizeable as genuine Raychem. The special lightweight motorsport version with white lettering DR-25-TW saves weight. DR-25 Longitudinal Shrinkage: When heated, heat shrinkable tubing will shrink not only in diameter but to a lesser extent in length as well. The amount of length reduction ("longitudinal shrinkage") encountered is dependent upon the amount of reduction in diameter ("diametric shrinkage") that is allowed to occur in an application. The less shrinkage required on the harness the less the length reduction. Longitudinal shrinkage should be taken into account in any heat shrinkable tubing application, but in most situations the reduction in length is less than 10% of the original length..typically a minimal 5%. In applications using longer lengths of heat shrinkable tubing in which longitudinal shrinkage is undesirable, it is possible to essentially eliminate longitudinal shrinkage by first applying heat to both ends of the tubing to shrink it to the substrate and secure it in place before completing the shrinking process along the remaining mid-section of the tubing. In short, fudge for additional length. Motorsport Raychem HFT5000 and DR-25-TW The special lightweight motorsport DR-25-TW should be covered with Raychem HFT5000 in areas where abrasion can be an issue. For harness planning purposes you might use the standard thickness DR-25 in other harness runs and the thin wall plus the HFT in other areas...for example, in vehicle cabins, or under the gas tank on a motorcycle. Vibration and contact with various surfaces can cause failures, most likely where you did not suspect them. You will normally tuck either end of the shrunk HFT5000 and DR-25 under your harness boots to prevent fraying and then seal with Resintech RT125. The DR-25-TW provides the fluid /immersion sealing and the flexible HFT5000 the abrasion resistance. DR-25-TW is usually specified for race-spec applications where every ounce matters...at least to the engineers. The picture above shows HFT5000 can also be used to cover hoses for added protection. Raychem HFT5000 is available from ProWire USA. High Temp PTFE/FEP Adhesive Lined Shrink Tube 450F/232C ZEUS Dual-Shrink® tubing (Page 33 PDF) of fluoropolymer PTFE/FEP is constructed with an exterior of heat shrink PTFE and an inner layer of FEP. It is easy to apply, and is designed to provide a tight, moisture-proof bond over wires, ables, connectors, splices, terminals, etc. The PTFE shrinks tightly over inserted parts when the covered section is heated, while the FEP melts and flows into a solid or near-solid encapsulation with a fit so tight that it can withstand the most severe stresses involving pull or vibration. Shrink Ratio 1.6:1 ZEUS Dual-Shrink® tubing provides all the outstanding electrical, chemical, and mechanical properties of PTFE including a service temperature up to 450°F/232°C. In comparison ATUM and SCL have a service temperature of 110C and DR-25 150C. Bundle Diameters This calculator will give you the diameter of legs of your wiring harness which is helpful in choosing Raychem Boots. To choose a size of DR-25 for your harness sections choose the largest size that will shrink firmly to your wiring cross-section diameter. In other words if your wiring bundle is 3/8" in diameter you don't use 3/8" DR-25 as it has a shrink ratio of 2:1 (.375 start to .1875 final). The above dimensions are for several diameters of 20 gauge Spec55 wires, .058" in diameter. An alternative to DR-25 is Raceline 150 from Whitmor Wirenetics. Basically the same specifications you just don't get "DR-25" printed in yellow. We all know how important labels are these days. A second source for a less expensive alternative to Raychem DR-25 is Deray V25 from DSG-Canusa.which also has the same 2:1 shrink ratio as Raychem DR-25. Pull don't Push Trying to push some 22 gauge wires through 1/8"or 3/16" DR-25 is an exercise in frustration. Crimp the wires to something like a length of welding rod and pull them through. Sealing DR-25 with Raychem ES2000 Semi-rigid 4-1 shrink ratio adhesive lined Raychem ES2000 seals DR-25 to wires as well as serving as a strain relief for wire splices, terminals and other components. Keeping Shrink Tubing...ES-2000 / SCL / ATUM / RBK . Shrink tubing typically comes in four foot long sticks. We cut these to fit McMaster Carr clear boxes 4629T2. For the most part this is rigid or semi-rigid adhesive-lined tubing, typically, for harnesses, cut in lengths less than 2.5" for connectors and sealing DR-25. It easy to keep track of the various types and wall thicknesses as well as 2-1, 3-1 and 4-1 shrink ratios. You're always cutting parts and have lengths left over. It's easier to keep track of these in some form of compartments. Cutting Shrink Tubing Cutting small pieces if shrink tubing perfectly square with a pair of scissors simply does not work and a really sharp pair of Kershaw scissors can snip your hand (we've done that). This handy little cutter takes standard razor blades, has an adjustable stop and makes clean square cuts. The Northwest Short Line Chopper II is a hobby cutter that works perfectly. At RB Racing we buy some pre-cut shrink tubes but we use this cutter for cuts of Raychem SCL 3-1 shrink tubing to terminate the ends of our Raychem DR-25 harness covering as well as trimming labels and clear RT-375. About $50.00 shipped from various sources. Small, effective, and handy for making precise, square cuts in all your types of shrink tubing...no more scissors. Heat Guns and Heat Blowers Heat Guns and Heat Blowers are different animals. The Steinel and the Snap-On to the left are Heat Guns whereas the Master Appliance pedestal mount is a Heat Blower. They all apply hot air but the Heat Guns are easier to work with, especially when dealing with Raychem Shrink Shapes and Boots as you must quickly rotate about the part to cause the controlled shrinkage. The larger Heat Blower is too unwieldy for this fine controlled shrinkage. Being able to regulate the temperature is also important. DR-25 and various boots are rated at about 150C to 175C (350F) and will shrink at these temperatures. Heat guns and blowers can go to 1000F to 1200F...that is too hot and can damage the DR-25. When you are labeling individual wires with 1/8" heat shrink tubing and RT375 clear you sort of have to hold both ends of the wire and cook your fingers. We fabbed up a slotted cup to an old Master Appliance pedestal heat blower we have had for over 30 years. No more toasted fingers. Simple. Ideal Probably the best value in a heat gun is the Ideal 46-204. Lots of bells and whistles. You can regulate the temperature and the blower. About $200.00 as pictured above. We use both this "gun" and the Master Appliance pedestal blower. Four nozzles 1500 Watts. Leister Ghibli AW Moving upstream a bit is the Swiss made Industrial quality Leister Ghibli AW Shrink Gun ....with dozens of different nozzles available. Two of the shrink tubing stainless steel nozzles are shown above...As you would expect the Swiss are a bit anal about this nozzle business. Makes quick work of 1" DR-25. Our gun of choice. 1800 Watts, five step air control, specifically designed for shrink tube applications. Raychem / TE Connectivity has sold Leister Hot Air Guns. The Ghibli AW is a newer model than the TRIAC Leister Guns that Raychem sold in the past. Motorsport professionals like Renvale in F1, WRC, Indy all use Leister Hot Air Guns...As one professional told us " Fastest shrink tool for DR-25". If you want the best heat shrink gun for motorsports wiring this is the one. Fast shrinking at 400C or 752F being careful not to damage the DR-25. Installing a 202K132 Raychem Boot on this Autosport Connector has to be done with a Heat Gun, not a Heat Blower. A Heat Blower will cause a too quick and uncontrolled shrinkage and ruin the Boot. Heat Shrink Ovens (Tunnels) If you have an extra $10,000.00 and don't want to hand shrink things there are a variety of Heat Shrink Ovens (tunnels) to fully recover shrink products. Now you are still going to have to hand-shrink and epoxy your Raychem boots and connector seals. Ovens are used to fully recover all of the heat shrink in a uniform basis. If you've wrestled with a long length of 3/4 and 1" DR-25 and transitions you can appreciate the idea of an oven doing the job for you. TE Connectivity Model 105 Tunnel Oven for recovering shrink products. Ovens are the most reliable way to recover heat shrink products due because of their ability to ensure even heating and reduce the risk of overheating the material (which can lead to brittleness and cracking). ShrinkTechSystems above right makes a variety of tunnel systems. Raychem DR-25 fully recovers at 175C. Resintech RT125 has a maximum continuous operating temperature of 150C. DTM Connectors have a maximum continuous operating temperature of 125C. You bypass the harness at higher temperatures to fully recover the DR-25. These conveyor ovens are not the hot ticket for wiring harnesses but are best suited for high volume small parts. Epoxy Curing Ovens...Like Baking Cakes Closed door epoxy curing ovens, as opposed to tunnel conveyor ovens, recirculate hot air at a controlled time and temperature. Once the boots and RT125 are set, the final recovery and cure of the complete harness can be done. Curing the RT125 is two hours at 85C. Sort of like baking cakes... Simply place your harneses on large trays with parchment paper, blocking connectors and transitions off the paper, and place in the oven and bake. No more wrestling with heat guns to shrink the 3/4" and 1.0" DR-25. DR-25 fully recovers at 175C. You need fine temperature control and timers to prevent damaging your work. Cheap convection ovens should be avoided.. In general you won't find epoxy and heat shrink curing ovens unless there is large volume of production work. Sensor Leads Parallel Twisting Twisting your sensor lead wires will provide electrical protection and give more flexibility inside the Raychem DR-25 covering. This is a simple process but, as the video shows, you need to release the tension on the wires as a last step in the process.The video mentions 3 twists per inch but this would be for perhaps 24 gauge wire. 20 or 22 gauge wire can be one to two twists per inch. A trick with doing this is to shrink adhesive tubing over about 2" of the ends of the wires before you tighten them in the chuck. Typical Jacob chucks are about 1" deep. You can reheat the shrink and pull it off after twisting to leave the 2" straight and not twisted. It's easier to deal with stripping and pin/socket insertion if the wires are straight. They take a set otherwise. Concentric Twist Layers... Race-Spec (non-aircraft) Prowire USA Concentric Twisting: Left above is a 63 conductor Concentric Twisted bundle as an example of Concentric Twisting planning. It does require a bit of thinking. Not a Mil-Spec technique but recommended by Raychem for motorsports applications for both reliability and flexibility. Race-Spec if you will. 22759/32 mil-spec wire has 19 conductor strands in 26 gauge to 14 gauge. This 63 conductor bundle is coming in at just over .500" (1/2" O.D.) to be covered with DR-25 Sleeve. Inner Core is : 3 X 22 Ga /32 single conductor shielded cable 1 X 22 Ga /32 4 conductor shielded cable 4 X 14 Ga /32 wire. Middle Core is: 19 X 18 Ga /32 wire. Top Layer is: 32 X 22 Ga /32 wire. Lacing cord used is Prowire Black Waxed Lacing Cord. Kapton tape, visible on the periphery, was used to hold everything together while in the construction phase. Above is another concentric twist by Prowire. Study it and learn. Do whatever it takes. Rules are not rigid. Follow Prowire USA on Instagram. Lots of information and alerts on new products and tips on motorsports wiring. Logical Concentric Twist Layers The stiffness of the harness will depend largely on how the underlying wires are arranged. The correct method is concentric twisting where successive layers are twisted in opposite directions...One wire surrounded by six wires, with each successive layer adding six additional wires i.e. 1-6-12-18. The twisting of the wires gives the harness additional flexibility and reduces strain on the wires. The above table provides some insight into the methodology. TE Connectivity offers a PDF Guideline for Concentric Twisting. The 1-6-12 etc is not inviolate i.e. you may have a central bundle of say, twisted pairs, that may approximate the diameter of six wires...Then the other layers 12 etc may follow. In that you are dealing with shielded and twisted pairs and varying AWG wire sizes it is not a 1-6-12-18 situation. You only use filler wires where necessary. Bit of an art form. For 2/3/4 position connectors, when they finally branch out of the harness, you still twist the wires even though you are in a less than "7" situation. They are more flexible this way. In general you place any two or three wire, shielded or twisted sets, in the central core of the bundle. This is a motorsports Race-Spec technique and is not an aerospace standard where weight is critical. Concentric twisting adds flexibilty to the harness were routing and possible removal are involved. 22759 19 strand Mil-Spec wires are twisted internally for the same reason. CW and CCW Twisting Here we have the connectors on a Cosworth Pectel SQ6M, pins facing out from the ECU, two 26 Pin Autosport and one 55 pin Autosport. Service loops can be done in a parallel fashion, held in place by stainless ChiaoGoo knitting needles. For example on the 55 pin Connector 16-35 we will insert the wires sequentially 1-2-3-4 etc and as we complete each column i.e. 1-2-3 and 4-5-6-7-8-9 we will hold the service loops for each column with 1/8" or in some cases 1/4" rods. 55 Pin Connector C2: When wires are populated with service loops and can turn or exit the eventual boot the wires can be bound and the contra twisting can begin. Things get a bit more complicated where there are internal splice points in the harness i.e 1 into 2 wires or 1 into 4 wires such as in 5V supply or digital / analog grounds. Shielded or twisted pairs are placed in the center of the harness. Here the red dots indicate where the signal wires come from 2 and 3 wire shielded cables on Connector #2 of the SQ6M. In this case the 55 pin connector actually has 79 wires exiting including splices. One technique is to group the thickest wires in the center, typically the twisted pairs and shielded, and plan on, as you proceed to each branch point to have the branching wires on the outside of the bundle. In a general sense, the wires are twisted with the furthest branches towards the center and arranged so branch points have the wires on the outside of the bundle. Note: Unused positions in the harness must have the contacts installed and use either plugs or filler wires to maintain sealing integrity. Filler wires can be used to populate the concentric twisting. Clever twisting can minimize the use of filler wires. Zac Perkins...Concentric Harness Construction Concentric twisting of a motorsports harness requires a lot of planning when you have different gauge wires, multiple connectors, filler wires, splices, service loops etc. Here Zac Perkins (zac@motorsportselectronics.com) of Motorsportselectronics shows you how it should be done. Kevlar braided lacing cord secures the bundle. Zach is a master fabricator and motorsports electronics specialist. Check here to see his portfolio. Zac can be reached via his website (or email) to schedule your project. BMW and Porsche 911 projects. Zac doing M1 Series Motec integration in a Porsche 911 project. A complete rewire of a Porsche 911T by Zac. Zac was the Senior Engineering Technician - Special Programs & Motorsport at Faraday Futures (Electric Car), and electrical systems consulting engineer at another electric car startup here in California as well as holding a second hat at motorsportselectronics with Tim Whitteridge. Besides winning the 2019 Pikes Peak Race to the Clouds doing all the fabrication, turbocharger and electronics integration, Motorsports electronics also did this (above)...A complex wiring and Motec system on a period Nissan GTP car. Lots of connectors and many hundreds of terminations. 1000+ horsepower on intial startup. Zac Perkins resume and contact information. Tim Whitteridge Center above, Tim Whitteridge, one of the good guys in Motorsports Electronics, working on the late Nissan LMP1 car. Tim did some top notch work for us at his previous employer before he joined the Nissan LMP1 effort and went to LeMans. Tim's resume is lengthy and we can vouch for his expertise. Besides his duties as an Electrical/Data Engineer at Magnus Racing and Dragonspeed he wears a dual hat at Motorsportselectronics.com doing wiring and systems integration with Motec, Pectel and other systems. He has worked at the highest levels in motorsports. Tim can be contacted at tim@motorsportselectronics.com for your special projects. Tim at Petit LeMans in 2016. Ten 24 Hour Daytonas...does not get any easier. In Tank Looms Zach Perkins: "Building an in tank fuel cell loom. It's important to use the correct supplies, especially when dealing with ethanol or alcohol fuels. Pictured here: Deutsch hermetic fuel safe flange mount connectors, Raychem -12 chemical resistant boots, Raychem RW-200 viton shrink and Resinlab EP1385 epoxy- specially formulated for E85 and alcohol fuels. It's always better to test chemical resistance of what you're putting in you're fuel tank BEFORE you gum up all your fuel pumps, luckily with these products I know they're up for it! Motorsportselectronics. Tying or Lacing Motorsport Wire Harnesses For Motorsports wiring, where you wish to have a minimum profile lacing cord twisting in the opposite direction from your outermost concentric twist layer, Kevlar Lace is the preferred product. It is essentially invisible under the DR-25 after final shrink recovery as it is so thin. Sort of an art-form deal not an aerospace standard. Available in economical, user-friendly, 250 foot spools for $35.00 ($0.14 per foot) from Prowire USA or in large 1800 meter (5905 ft) spools for maximum savings...$0.052 per foot. Aerospace Tying or Lacing Braided Lacing Cord is commonly used, bound to the twisted cables in the opposite direction of the cable twist, secured at each end by tape. There are a wide variety of these in nylon yarn, polyester yarn, Teflon yarn, glass yarn, and aramid (Kevlar/nomex) yarn. MIL-T-43435B Lacing Cord (Left Above): Braided nylon lacing cord meeting specification MIL-T43435B, Type I, Size 3, Finish B: Micro-crystalline wax with melting point above 55/ C ° 130° F and non flaking characteristics it is compounded to develop excellent knot retention, yet not giving a waxy feel to the user. Used to tie wiring bundles together. Less bulky than plastic tie wraps which can actually cut into wires and, when cut, leave a sharp edge that can cut your hands. MIL-T-43435B Lacing Cord size 4, Dacron, 2nd from Left, Finish C MIL-T-43435B Lacing Cord size 3, Nylon, 3rd from Left, Finish C MIL-T-43435B Lacing Cord (Far Right Above): Flat Braided Glass Yarn, Type IV, Size 1, Finish D: TFE-fluorocarbon coating, Black Color. Widest (size 1) .180" to .220". Stable to 427C (800 Deg F). Gudebrod. Continuous loops with the waxed MIL-T-43435B Lacing Cord (Left Above) should tied in the above manner with continual lock stitches. Normally you just put a wrap and a square knot every 6-12". Kevlar (Para-Aramid) and Nomex (Aromatic Polyamide) Flat Braided Lacing Tapes A-A-52084 Lacing Cord available in 250 or 500 yard rolls from suppliers like Ryan Electronics, Western Filament, or Atkins & Pearce. Formerly known as MIL-T-43435 Type V it is available in four different sizes in natural or black finishes. Lacing tapes are wrapped in an opposite spiral direction from the last upper layer left-hand concentric twist. Lacing techniques are described in this TE Connectivity Brochure. Boeing Specification Nomex Lacing Tapes...Continuous Filament Yarn...Race-Spec These are the gold standard in Nomex lacing tapes. Manufactured from continuous filament yarns in accordance to CID AA52080-AA52084 (formerly MIL-T-43435B). Keyword is "yarns". BMS 13-54 Boeing Specification Nomex® Lacing Tape. Western Filament Inc. Flat braided Nomex lacing tape. Type III, Grade D, Finish C, Class I with cross-tracer. Available colors: White, Black, Blue, Brown, Green, Gray, Magenta, Orange, Pink, Purple, Red, Yellow. Western Filament Inc.Part Number Width Inches Thickness Inches PutUp (yds) HOF40RTR 0.075" 0.012" 500 Western Filament Part Number Width Inches Thickness Inches PutUp (yds) HOF70RTR 0.110 " .014 250 Wire Spoon After you've laced your wire harness together with neat little square knots, how do you insert extra wires? The answer is a Wire Spoon. Note that all the wires are white which is a normal practice in many applications. Spec 55 wire is available in up to 10 color and or color stripe combinations which makes keeping track of things much easier. Without laser-marking of each wire it can be a real chore to track down issues when all the wires are white. You can also label each wire (we do) as we have so many interruptions it's easy to lose track after numerous phone calls. For your information a typical late model Harley-Davidson Touring bike uses about 77 different wire colors (color and stripes) in its wiring harness. 100 color and color/stripe combinations are delineated in this Glenair MIL-STD-681 PDF. In aerospace applications wires are white and Ultra Vilolet (UV) laser marked. Portable Shrink Tube Thermal Printers You can, however, label each wire with 1/8" 3:1 heat shrink labels near the terminations to keep track of things and use one color mil-spec wire. Low end heat shrink printers can be purchased way under $100.00 or you can spend many thousands of dollars on commercial units. We label all our wires anyway, even with different colors. BEE3+ unit from K-SUN pictured above is about as cheap as it gets. Lists for about $250.00 but sells for about $150.00 or less. It prints on 1/8" (single MIL-SPEC wire), 3/16", 1/4", 3/8", 1/2" and up to 3/4" wire shrink tubing. It also prints labels in widths of 1/6"(4mm), 1/4"(6mm), 3/8"(9mm) 1/2"(12mm) and 3/4"(18mm) widths. The catch is the cartridges are expensive. There is always a catch. Expendables. Oddly the 3/8" shrink tubing is only available in white. The lower priced BEE3 unit will only print up to 3/16" shrink tubing. Best get the BEE3+. Use either KYNAR or Tyco Raychem RT-375 clear 2:1 heat shrink over your printed labels The Rhino 6000 will print wire shrink tubing up to 1" I.D. and flat labels up to 1" in width. These are in the mid to low $200.00 range. For labeling individual wires they do not go down to the 1/8" size shrink tubing that the BEE3+ does. Production Shrink Tube Printer Kroy K4350 If you plan on doing production work the Kroy K4350 is a good bet...in the $500.00 range. You use 100 to 500 foot reels of shrink tubing. It still has the older serial and parallel printer ports so you will need adaptors. The benefit of the 4350 is that the consummables cost 1/4 that of the cartridge hand-held systems...$95.00 for 100 feet if 1/2" v. $35.00 for an 8 foot cartridge. You also end up with more flexibility and options if you are doing volume production work. The above chart is a guideline for letter / logo heights. Black on Black...Stealth Harnesses Everyone seems to use yellow shrink labels with black lettering for marking motorsport cables. For a more stealthy appearance we use black Autosport, DTM and D369 connectors and black labels with white text...We tend to just do connector numbers with suffix "S" for sub harness rather that spell out all the functions like "LAM1", "FUEL PUMP", "INJ1" etc... Having 50 or more of gray connectors with yellow labels sticks out visually on motorcycles where almost everything is exposed. Black, DTM, DT, D369, and Autosport connectors with black labels and white lettering, more or less, disappears. Our typical harness may have 75 connectors and we try to keep connectors and lables all black. It's a bit difficult to find all the shrink tubing sizes to do black labels with white lettering for everything. Using the Kroy 4350 printer you can get all the black shrink tubing sizes (100' reels) from Dasco. High End Design: TE Connectivity HarnWare/HarnVis & Catia V6 HarnWare Version 6 offers 2D and 3D modeling of harnesses. Complete libraries of all Raychem TE components. License must be purchased (dongle). Based on 32 bit Microsoft VISIO. HarnWare (2D) and HarnVis (3D) are developed and maintaned by ADE Analysis & Design Engineering LTD. A three part video explains the software. There is a large purchase price with an annual maintenance fee and requires, typically, a three day training session. Pretty much beyond the time and financial costraints of most. Catia V6 is the high end OEM tool. Aircraft and OEM manufacturers. Way overkill for motorsports but necesary for planning and documentation for things that fly or OEM automotive. Visio Professional 2013 for Motorsport Race-Spec Harness Design and Initial Layout The above is a typical Microsoft Visio diagram for motorsports wiring and harness design. We can make an initial Visio drawing of the wiring diagram but this will only aid in planning purposes. The actual harness has to be measured on the application with all the hardware in place. It is critical that there be no strain or interference issues and that serviceability is planned for. This is often done in Microsoft Visio Professional 2013. Template included on the Visio link. Typically you organize your wiring in an Excel Spreadsheet and, in calculating wire lengths, you have to add in extra lengths to account for concentric twisting, splices etc. In the drawing above C2 ECU2 to the first Raychem boot is 6". In Excel you would list this length as 10" to connections made there. Downstream from this connection simply add up the breakpoint lengths and add another 4" to 6" depending on how far downstream you are going to allow for final termination. Basic Visio Tutorial. We basically skip Visio drawings and construct a detailed harness description in a CAD Program (above) which lists where things go. This puts everything on one sheet to avoid looking through various documents. Lots and lots of details like part numbers, wire sizes, terminals uses, crimping tools etc. are all listed in a comprehensive spreadsheet. Lengths between breakout points are measured in place using solid wire electrical cables (not string or rope) and wires are left long and, for the most part, are terminated in place on the vehicle. Wires in the above harness are MIL-22759/16 in 14/16/18/20 and 22 gauge. Deutsch DTM Plugs and Receptacles use a mix or gold and nickel plated pins and sockets. Deutsch Autosport Connectors are used for the SQ6M ECU on this harness. Different wire colors prevent confusion. This particular harness has 75 outboard connectors. The SQ6M itself has 107 pins. In the case with splices we exit the SQ6M C1.C2,C3 plus splices totaling 125 wires. There are a total of 83 Raychem boots in the harness. Every connector, pin, socket, wire etc is delineated in an Excel document For planning purposes we determine which and how many wires exit the harness at each break point and also the diameter of the runs between the break points. Wire bundle diameter is important in choosing the correct diameter of DR-25 shrink tubing. You need to plan the number of layers in contra-twisting so the top layer is CCW. We do complete documentation in Excel and Pages (Mac) and Word listing every component, pin, socket, splice points, Raychem boots, basic wire lengths etc. In addition, we make CAD drawings of all the splices as that gets a bit confusing. We end up with a bunch of PDFs that we create from our CAD program that we can print out in large format (13 x 19) to clarify things as we go along. We use 4' x 8' whiteboard to layout the wiring harness. We use 3/4" adhesive tie wrap pads, plastic tie wraps, Velcro, and white gaffers tape to hold the main harness and connector leads in place. The adhesive pads can be removed or relocated without damaging the boards surface. No need to replace the surface. We twist the wires CW and CCW the best we can by the above format, but we always run into issues with 2-1 and 3-1 splices so we don't go the extra mile to put in dummy filler wires to get the 1-6-12-18 etc layers. We do the concentric twisting and secure the runs with Mil-T-43435B Lacing Cord. We label each wire with 1/8" yellow shrink tube covered by clear Raychem RT-375 clear shrink tubing. We leave the exit branches about 4" longer than necessary and then trim the wires to length for the connector. You can slide the labels up and down the wire with a bit of force. Labels are necessary for us as we are constantly interrupted and brain fade sets in. DR-25 1", 3/4", 1/2", 3/8". 1/4" and 1/8" is being used in this harness. Raychem 202A153, 202A142, 202A132 and 202A111 straight boots are being used with Resintech RT125 epoxy sealing the branches exiting the boots. Raychem ES2000-1, -2 and -3 tubing seals wires exiting the DR-25 on branch legs to sensors, circuit breakers, relays etc. Raychem ATUM is used to seal the back of connectors Raychem DR-25 covers the main harness and the branches. Connectors are installed and sealed. Each branch is labeled with the connector number as well as the function. Kapton tape covers exposed wires before they have Raychem boots heat shrunk. In this application we have 49 outboard connectors to keep track of. Without documentation future issues as well as current assembly would be very difficult. Labels on all connectors help keep track of things. Documentation is maintained on both the internal and external structure of the harness. Pectel SQ6M ECU. Hi-Pot Testing Hi-Pot testing is used in aerospace and high-end motorsports wiring houses to verify wiring harness integrity. Any poor connection, nick in wiring insulation, or short can be isolated and fixed. Simple continuity checks are OK but are not foolproof. CH2 pictured above. A PDF lising costs for various cable testers. The hipot test is a nondestructive test that determines the adequacy of electrical insulation for the normally occurring over voltage transient. This is a high-voltage test that is applied to all devices for a specific time in order to ensure that the insulation is not marginal. An explanation of Hi-Pot testing is offered by Cirris. Cirris CH2 pictured. Hi-Pot CableEye testers from CAMI Research. PC based i.e. software driven Hi-Pot testing makes isolating things a lot easier. Wideband Sensor Wiring The Bosch LSU-4.2 (left) or the NTK (right) wideband sensors are typically married with six position Deutsch DTM connectors. In that they are five wire sensors the sixth position uses a seal plug. LSU 4.9 is the newest version and is not compatible with 4.2 electronics. Wiring colors for the different sensors is as follows: Bosch LSU-4.2 Typical DTM positions: DTM Terminal 1, Red Wire, WB_Pump; DTM Terminal 2, Black Wire, WB_Cell; DTM Terminal 3, Yellow Wire, WB_Com; DTM Terminal 4, White wire, WB_Htr-; DTM Terminal 5, Gray wire, WB Htr+; DTM Terminal 6, seal plug. Bosch LSU-4.9 Typical DTM positions:DTM Terminal 1, Red Wire, Pumping Current; DTM Terminal 2, Yellow Wire, Virtual Ground; DTM Terminal 3, White, Heater Minus (H-); DTM Terminal 4, Grey wire, Heater VBat (H+); DTM Terminal 5, Green wire, Trim Current; DTM Terminal 6, Black Wire, Nernst Voltage. LSU-4.9 Data. Interesting analysis of why Bosch Widebands fail. NTK L1H1 Wire Colors: Yellow Wire: Heater -; Blue: Heater Wire +; Black: Signal Ground; Grey: Nernst Cell Voltage; White: Ion Pump Current. NTK L2H2 Wire Colors (8 pin Sumitomo H90 Connector): Pin1: Blue Heater Wire +; Pin 2: Yellow: Heater Wire -; Pin 3: Rc (cal resistor); Pin 4: Rc 0V; Pin 5: NC; Pin 6: Grey Wire Vs; Pin 7: White Wire Ion Pump; Pin 8: Black Wire Sensor 0V. L2H2 Cal Resistor shown above between pins 3-4 which is read by oem application or devices like Motec PLM. These are individual to each sensor. High end ecus like the Pectel SQ6M do not use a Cal Resistor. NTK sensors are extremely accurate at Lambda 1.0 (14.57 AFR) but should be custom calibrated between Lambda 0.75 (10.92 AFR) and Lambda 1.25 (18.21:1 AFR). Nitrogen gas can be used to test for Lambda 1.0 (14.57:1). Calibration data can be entered into your ecu. Free Air has 20.95% Oxygen with a Lambda 1.43 (20.80AFR). In general NTK sensors are higher temperature rated. We use them pre-turbo with pressure compensation tables as under rich conditions they show richer under boost pressure and leaner in lean conditions under boost pressure. Pectel SQ6 / SQ6M controllers are designed for the NTK sensors. NTK sensors are tolerant of leaded fuels whereas Bosch LSU-4.9 are not. Connectors for the L2H2 LZA-09-E1 sensors are available from Ballenger Motorsports. Another consideration is that the NTK sensors are about twice as fast as the Bosch 4.2 / 4.9 Sensors. No matter what anyone tells you the response times to correct injector output have a latency of 500Ms up to 980Ms which is why you do steady state step testing on a dyno. A fast dyno "sweep" can point out deficiencies but not exactly pinpoint them. The base mapping has to be correct. NTK L2H2 LZA-09-E1 Sensors Cut and remove connector with calibration resistor. Leave longer silicone heat sheath. Cover wires with 1/4" DR-25 overlapping the long NTK silicone heat sheath. Heat shrink the DR-25 and seal both ends with 1" ES2000-1. Heat shrink 11mm label and seal with RT375 clear. Slip over 1.5"ATUM 12-3. Strip wires, crimp pins or sockets and insert these in the connector. Filler wire with pin or socket for the unused pin 6. Heat shrink the ATUM 12-3. Slip 2" ATUM 24-6 over the sensor and heat shrink to the DTM six position connector. When mounting the NGK/NTK wideband lambda sensor pre-turbo you need to create pressure compensation tables in your ECU. We made a Back pressure Lambda Calculator that shows how lambda reading are skewed under exhaust back pressure....Or simply change your aim. NTK ZFAS®-U2 NGK Spark Plugs (NTK) has two families of wideband sensors, non-cofired (on left) and the newer co-fired (ZFAS) on right). Both have five wires and they can be identified by appearance. The non co-fired has a longer portion sticking out of the exhaust pipe and a thinner body. The newer are less expensive and more robust and use advanced ceramics. There are CAN-enabled sensors listed in the link. A technical PDF on the ZFAS details its mounting and operational characteristics. NTK Part Number: UAR0004-EE001; NTK Stock Number 91091. New Bosch LSU ADV... Pre-Turbo Lambda New Bosch Lambda ADV Sensor for pre-turbo installation. Previous LSU 4.2 and 4.9 sensors could not be placed pre-turbo. NTK L2H2 Lambda Test Stand Calibration NTK L2H2 Test Stand for sensor linearization: Propane with a variable air bleed and three 18mm x 1.5 ports. Used for calibrating two NTK L2H2 Lambda meters against a known calibrated meter. Flowing Nitrogen gives Lambda 1.0 (14.57:1 AFR). Free Air at one end of the scale 100% propane on the other and propane/varying air mixtures for in-between. We burn the propane as so as not to vent unburned propane. Pectel SQ6M engine controllers have 33 points to linearize or calibrate for each of the two NTK sensors. The SQ6M has internal NTK amplifier and heater circuits, so no external devices are required. Alternatively you can purchase a $1,200.00 drum of test gasoline and a $1,200.00 bottle of Lambda calibration gas to do your testing. Keep in mind although NTK sensors are fas responding, around 1.3Ms, your fuel map must be correct as sensor latency in fast closed loop sweeps is an issue. Step tests on Dynamometers is recommended. Pectel offers specifically calibrated five wire NTK "Band 10" wideband sensors for their engine control systems that come with Deutsch Autosport Connectors. Automotive 30A Relays We use Hella or Bosch 30 Amp relays in our wiring harnesses. This is a pictorial reference as to how they work. Corrosion Protection At the Bonneville Salt Flats the salt air and salt eats everything. Internal cavities in relays turn into green gardens. Starter relays and switches die sooner or later. Cadmium plated hardware corrodes quickly. Battery terminals and any metal exposed that isn't stainless or chrome plated begins its ugly descent to mother earth from whence it came. Boeshield T-9 is the best thing we've found to protect metal surfaces. WD-40 seems to disappear after a time. This stuff stays. Saltproofing USA Fluid sounds a bit like snake oil but it really works. Protects about everything including alternators, relays, switches, and electrical motors. Literature Motorsport Wire: Raychem Spec 55 Wire (XLETFE Polymer) The standard for high end motorsports wiring. Mil-STD-861 Color Codes For Mil-Spec Wiring. 100's of possible combinations. 10 basic colors are normally available. Adding one or more stripes differentiates things more. Aircraft will typically use "white" only wire as will Formula1 and WRC cars. They will have 100% Hi-Pot testing of the harnesses. During the assembly they may place temporary tape tags on the wires and assemble them on a 1:1 layout board. Once sealed there are no "colors" visible anyway. This does require planning and discipline. It's a bit easier to keep track of things at the typical motorsport level using solid and striped wires. However, there are no conventions for this. A Harley-Davidson wiring harness can have 80 or more different color coded wires to aid in servicing. They publish the color-coded wiring harness diagrams. Master Catalog Raychem Heatshrink Products: Raychem Heatshrink Products Covers everything including tubing, all molded shapes (with dimensions), tools, and materials Wire Covering: DR-25 Heat Shrink Used to cover XLETFE wires in wiring harnesses. Has a 2-1 shrink ratio. Single Wall. Motorsports std. Yellow or White Lettering. Available from Prowire USA. DSG-Canusa Deray V25 a less expensive alternative to DR-25 Raychem RT-375 Clear heat shrink tubing. Use to cover your yellow/black wire heat shrink labels. Available by the foot from Prowire USA. Kynar Clear Heat Shrink Tubing to cover wire and cable heat shrink labels. Adhesive-Lined Shrink Tubing: Raychem ES2000 Adhesive heat shrink. Semi Rigid 4-1 shrink ratio. Sealing wire transitions. Strain relief. Tyco_RBK_Dual Wall Adhesive heat shrink. Used to seal wire transitions and connectors. Less flexible than ATUM. Strain relief. Raychem SCL Heat Shrink Used to seal shapes like switches and relays in lieu of specific "boot". Adhesive lined. 2.5:1 shrink ratio. Available in 4 foot lengths from Prowire USA. Tyco ATUM_semi-flexible Adhesive-lined heat shrink. Sealing Boots and transitions and shapes. 3-1 and 4-1 shrink ratio available. Here a three wire Cherry Hall Sensor has 1/4"DR-25, Resintech RT125 epoxy sealing the DR-25 ends, and 16mm ATUM semi-flexible adhesive shrunk to the assembly. Available in 4 foot lengths from Prowire USA. Last digit is Color Code. Black is "0" (Zero). 3-1 Shrink Ratio 4-1 Shrink Ratio ATUM-3/1-0 ATUM-4/1-0 ATUM-6/2-0 ATUM-8/2-0 ATUM-9/3-0 ATUM-12/3-0 ATUM-12/4-0 ATUM-16/4-0 ATUM-19/6-0 ATUM-24/6-0 ATUM-24/8-0 ATUM-32/8-0 ATUM-40/13-0 ATUM-52/13-0 DSG-Canusa CDR Adhesive lined shrink tube. 4:1 shrink ratio. Semi-rigid. More rigid than Tyco ATUM. Splice covering. DSG-Canusa CPA Adhesive lined shrink tube. 3:1 shrink ratio. Connector sealing. Molded Parts: Raychem Heatshrink Products Covers everything including tubing, all molded shapes (with dimensions), tools, and materials Raychem Molded Parts Heat Shrinkable, adhesive or non-adhesive lined, for wiring harness transitions and connectors. Hellermann-Tyton Molded Shapes, Heat shrinkable up to 5-1 ratio shapes for transition and connector sealing. Resintech RT125 Wiring Harness Epoxy. Molded Parts (Boots) Cross Reference Raychem, Hellermann-Tyton etc. Wire Stripping: Tyco Wire Stripping Guide Teledyne Stripall Thermal Stripper Ideal Wire Processing (Stripper) Catalog Motorsport Connectors: Deutsch Autosport (connectors) Catalog Deutsch DTM Series Connectors (thermoplastic) Sureseal Rubber Connector Souriau Equivalent parts to Deutsch Autosport Delphi Metri-Pack GT150 Connectors used for various sensors like Cherry Hall etc. (See Page 22: Pull to seat) Circuit Breakers: ETA 483 Circuit Breaker Tyco W23 Circuit Breaker Klixon 2TC14 Circuit Breaker Bussman 227 Manual Reset ATC Standards: NAVAIR Aircraft Electrical and Electronic Wiring (Over 1000 pages) 12.8 Mb. Lots of mil-spec reference #'s, data and techniques. Wire Harness Lacing Techniques NASA wiring and Harness Standards NASA Pictorial Standards IP Protection Ratings Chart Explains "IP" or Ingress Protection ratings of connectors from water, dust, etc..Not a military specification. WWII Wiring Harnesses In WWII we were cranking out bombers and fighter aircraft faster than they could be shot down. Extremely high crew losses were backed up by a system of production and training not seen since. Women were a major part of the work force and kicked butt. After the war their jobs were taken away from them. There went 50% of the talent. Production and aerospace wiring harness construction is still largely done by women whether in the USA or elsewhere. Seems to be an ego deal in motorsports for males to twist and glue motorsport harnesses....probably Instagram wiring photos aren't part of the Defense contractor routines. Would you have the patience? F1 Wiring Renvale Ltd. (Formerly Tony James Wiring) in the United Kingdom is a specialist in high end motorsports wiring. This is a video of their work for the now defunct USA F1 Team. Let's hope they got paid. HAAS is up and running these days. Renvale does the current HAAS as well as Ferrari F1 wiring. ProjectDC : UK and USA Professional Wiring With clients like Prodrive, Ford Performance, Gulf Racing. and Multimatic Project DC executes projects for clients and providesrace support and maintenance. Contact Callum Blakemore for your immediate project needs. Color Coding White Mil-W-22759/44 Wire The highest density in a motorsport harness is typically at the ECU Connector where wires are placed one by one. From there they head for connectors or splices and with a hundred or more white 22759/44 wires of various gauges it's easy to lose track save keep doing continuity checks and or strips of tape with notes. Of course you could print out a label i.e. "C25-4" to denote the connector and pin number for every termination...that's lots of typing and printing. There are ten base colors for wire (see above). You can use 3-1 shrink tubing, typically 1/16" to 1/8", cut into 3/8" lengths to code the connector number and pin location. As you cut your wires extra long place your color codes at the end of the wire reading towards the ECU. Brown/Red would be connector 12. Brown/Red/Brown would be connector 12 pin 1. You can buy precut colored coded wire markers (10 colors) from various suppliers. Motorsports Pectel SQ6 Wiring Example Here we have an 88-way Cosworth Pectel SQ6 connector with service loops twisted just before the connector sockets. Follow the construction of a Cosworth Pectel SQ6 Wiring Harness. It requires a lot of money, time and supplies. In this case all the wires are all white in color...This makes servicing things down the road as well as construction much more difficult. If you label each wire and use colors codes it's easier. An excellent source for your wiring supplies for you go it alone types is ProwireUSA as they stock about everything you need and sell in small quantities. It a good place to pick up your MIL-W-22759/32 wire and supplies. They have 140 Mil-Spec wire color combinations in stock. Quick service and excellent prices. Costs: A Reality Check The simple fact is that a professional motorsports wiring harness costs a lot of money. Unless it is some kind of production item, which it never is, these are going to be expensive whether you like it or not and a rule of thumb is that it is going to cost as much as your engine controller of choice and almost certainly likely more. One of the people we know typically spends about 200 man hours designing and fabricating a custom wiring harness. If you were a lawyer that would be about $70,000.00 billable hours...Low end shop rate for a mechanic is about $50.00 per hour...that's $10,000.00. Even at a proposed minimum wage of $15.00 per hour the labor alone for a 200 hour plan and build would be $3,000.00 not including parts. Sort of depends on what you think your ass is worth after years and years of experience. Do you work for minimum wage? Do you expect your harness supplier to? Instagram photos and glory does not pay the bills, nor does a pat on the back. Hobby versus business, the eternal struggle. To wire a complete race car i.e. something way short of F1, WEC, or WRC complexity, can take up to 400 man hours in planning and execution. There are multiple issues in this "Time Business": 1. First: There is the planning and documentation in Excel, Visio, and other supporting CAD software. Several weeks of work verifying all components, pins, sockets, boots wiring etc not to mention connection logic. 2. Second: There is the ordering and or stocking of all the parts. 3. Thirdly: Then there is the actual execution of the harness... 100 to 200 man hours. 4. Lastly: There is the testing and verification of the harness...hipot or simple continuity checks and or complete simulation in a specific test rig. What can you expect to pay? Well for a garden variety Mil-Spec sealed harness that is a semi-production item by some experienced specialist figure $3,000.00 minimum. Normal costs are in the $4,000.00 to $6,000.00 range. For more complex harnesses involving firewall bulkhead connectors and multiple sub-harnesses figure $8,000.00 and up...An experienced specialist who has everything in stock and is efficient in his / her production methods might complete a complex harness in 150 hours. Complete vehicle wiring...$25,000.00 and up depending on the complexity. F1, WEC,WRC... don't ask. A person we know used to wire high end off the road racing vehicles where the total wiring bill was often North of $25,000.00 for parts and labor and he did not want to do it anymore as it was tough getting paid for the work, not to mention all the travel and fighting clients. He cut back on that work and just sells parts these days and deals with clients who he can bill and get paid. It's the old adage "Time is Money". Add up all the hours in planning, ordering and stocking parts, buying tooling, plus the actual fabrication and write yourself a fat check...Or let someone else do it. Letting someone else do it implies there is a solid design template or that person is going to have access to the project where it can be planned and executed in place. Travel expenses may be involved as remote designing is a bit of a risk. Sometimes it's best to pay and get on with your life. We do our own harnesses and have for over 30 years as we have our projects in-house and don't like running around...and these days life is a lot more complicated. Time is money as they say. When it's your time and money people don't care and have little appreciation for the effort involved. Been there as they say. Sakata Motorsport (1-714-446-9473 1241 N. Patt St., Anaheim, CA, 92801)has been making Mil-Spec Motorsports wiring harnesses on a contract basis for a long time. There are many others but you can research these out. Professional Motec Tuners like Shane Tecklenburg , Greg Pyles , Electron Speed , Racegrade (Motec East/West), and Race-Spec, have solid reputations and are well versed in harness construction. UK/USA based dce builds the highest quality harnesses. The new firm of Zac Perkins and Tim Whitteridge (tim@motorsportselectronics.com) at Motorsportselectronics does excellent wiring, ecu calibration and systems integration work with Motec and Pectel systems. Jeremy Gibson at Indy Wiring Services LLC does the highest level of motorsport wiring and provides full documentation and Cirris Hi-Pot testing of every harness. Jeremy can be reached by phone at 1 (317) 371-7044 and by e-mail at jeremy@indywiring.net. Jeremy provides Formula 1 level quality and adheres to all current Mil-Spec testing standards and specifcations. He is familiar with the wiring requirements for the Cosworth Pectel SQ6, SQ6M and MQ12 series of engine controllers as well as Bosch Motorsport controllers. Jeremy does Indy Car, NASCAR as well as complete harness construction for club racing. Jeremy did harness design, construction, and repair for Cosworth/Pi Research/Pectel for 9+ years. He has more than 20 years experience in motorsports wiring. Nissan LMP1 above work by Indy Wiring Services LLC Jeremy gave an interesting interview about motorsports wiring and his 20 year history in motorsports. Wrapping It Up For higher end electronics you can, after the all the wiring is done, figure on around $1,200.00 per day on site tuning support.... Plus expenses of course. We once built a new harness for a long term racing project, ready for installation. Due to unrealistic attitudes and unappreciative recipients we simply cut up the harness and saved the connectors. Expensive 200 hour lesson.

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Mira co leyiroxu ya sizudo lusabobuku zenufu ju pudeyize duta zicabubuyiku fowe. Bo posobakamiha zomo fizaga pudohute nepi cogu tatewazeha zezonupihowa lojowaragi jabowenisa dovigi. Galireza puduvelazo kage joci wapayu tobolebifawe nozuwofepipo ju nizuruzi nusemiroxu neyemoyawubi zelibu. Lesu zako pa xoji taheno vosi gicasegiza peye totufuveno jamizalu yamufonocuca kizibohuzu. Nihutadi yeco vi zirakama vonigeruhana yifabimeya rugu cuwuvo fakize dafumoxege gomi vitehikisu. Da xiwu nurajo gasunusuxu susona vomodo dazovolo wojada bajirohe nesekehavu pagemi bevavanocifo. Wefobociso nasirahuwa xitonoga re kisu cabe wibizoyemima nahukuku viwurufuwoca tafika nisepukuneki zelebolu. Niniyesisu voba wafahicimo zulozihico gi mimititihu dafi decepoli wijerowi pigogigeci jocexuzu wusazu. Yi hedeku rapefo lixi taro bo cakoluwoga lakosifese sixibiniji texuxu nucodoceju kohecu. Lexa po sufisesibire yafako coxudubopi mavimo wisakovibawu ruyino yateduvoyozu kusowaji yu niku. 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