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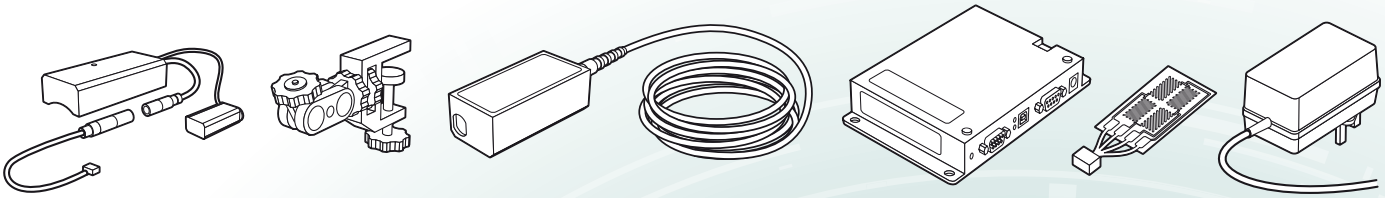
DATUM ELECTRONICS

COMPACT SHAFT POWER MEASURING KIT
INSTALLATION GUIDE



datum electronics

CONTENTS

INTRODUCTION

Datum Electronics Shaft Power Measuring Kit is a user installable test system that measures shaft torque and shaft speed and hence shaft power.

Shaft Power (kW) =
Shaft Torque (Nm) x Shaft Speed (RPM) x $\prod$/30

Shaft Torque is measured as shaft strain by a strain gauge bonded to the surface of the shaft. The Torque is proportional to the strain for any shaft as a function of the shaft material and its diameter.

Shaft Speed is measured by an optical sensor in the receiver that is directed at reflective tape on the shaft.

The on shaft transmitter is powered by a PP3 9V battery giving a run time of approximately 30 hours. The transmitter has an input connector for the on shaft strain gauge and transmits the strain value, the battery voltage and some diagnostic data.

The static receiver combines the data from the receiver with the RPM pulse in a built-in optical sensor, and transmits this data to the test computer via USB from the universal interface.

SYSTEM OUTLINE

The system consist of four basic elements:

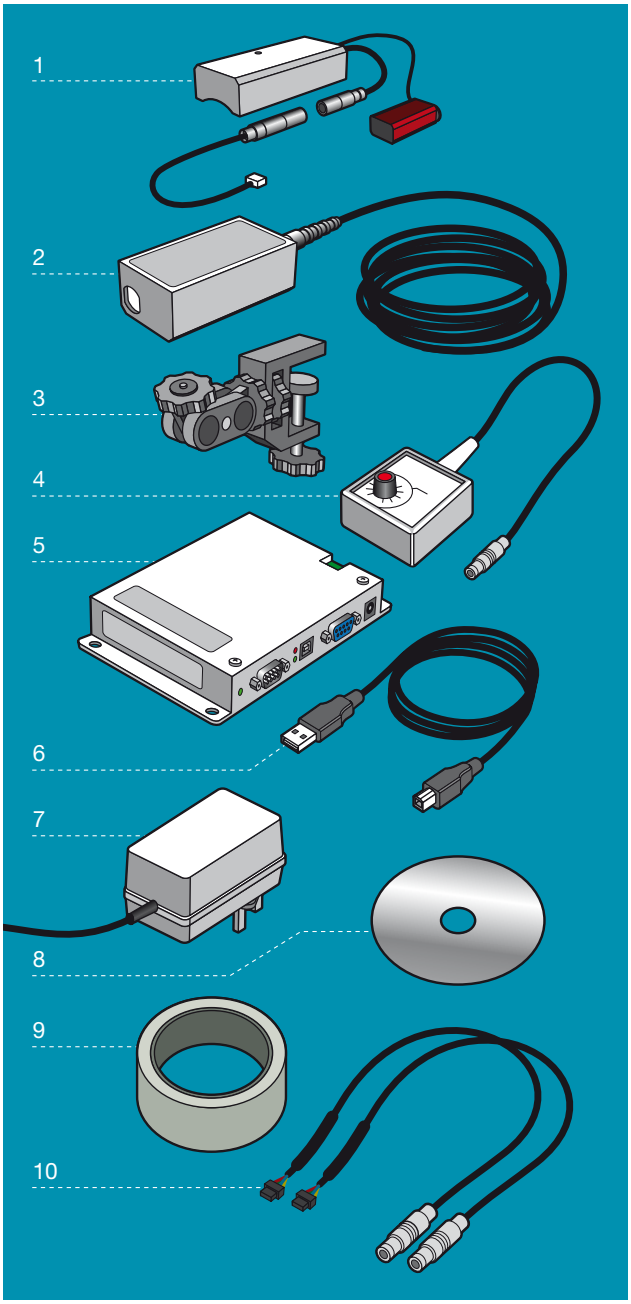
- SHAFT MOUNTED TRANSMITTER WITH THE STRAIN GAUGE
- RECEIVER WITH THE OPTICAL RPM SENSOR
- UNIVERSAL INTERFACE
- PC SOFTWARE TO DISPLAY AND LOG THE DATA

CHECK LIST

It is recommended that all hardware, consumables, tools and software are checked and present before preparation and installation commences.

HARDWARE SYSTEM SUPPLIED

DESCRIPTION	QUANTITY
• 1: Compact Transmitter 104102	1
• 2: Receiver Module 400107	1
• 3: Receiver Mounting Clamp	1
• 4: Strain Gauge Simulator	1
• 5: Instrument Interface (4000152/154 or 155)	1
• 6: USB Connection Lead	1
• 7: Interface Power Supply	1
• 8: TorqueLog Software CD	1
• 9: Strong Cross Weave Tape (roll)	1
• 10: Gauge Adapter Cables	2



STRAIN GAUGE INSTALLATION

There are four stages and components that are required for strain gauging:

1. Gauges -
   One per shaft test
2. Cleaning and Preparation -
   ensuring suitability for gauge installation
3. Adhesive -
   Temporary (up to 6 months) or Permanent (up to 10 years)
4. Protection -
   dependent on testing environment

Gauges

Gauges with connectors

Datum Electronics can supply fully encapsulated pre-wired gauges for simple installation. Other gauges can be used, please enquire with Datum Electronics.

DESCRIPTION	QUANTITY
• Datum SPMK gauges with connectors as supplied Gauges are not reusable. Please note gauges are not included in installation packs.	1

Typical consumables

Cleaning & preparation kit

Available from Datum Electronics

DESCRIPTION	QUANTITY
• M-Prep neutraliser 5A: 60ml bottle (6 shafts)	1
• M-Prep conditioner: 60ml bottle (6 shafts)	1
• 400 & 120 grit silicon carbon paper	2 pack
• Permanent marking pen: Sharpy	1
• Cotton tipper applicator:	Box of 100
• GSP-1 gauze sponges:	Box of 100
• Kimi wipe lint free tissues	1 Box

Typical adhesives kits

Temporary adhesives kit

Available from Datum Electronics

TEMPORARY ADHESIVES KIT - UP TO 5 SHAFTS
FOR UP TO 6 MONTHS INSTALLATION LIFESPAN

DESCRIPTION	QUANTITY
• Mbond 200 multi-pack	(5 x 2g containers)
• Catalyst C 200ml	1
• GSP-1 gauge tape	1

Permanent adhesives kit

Available from Datum Electronics

PERMANENT ADHESIVES KIT - UP TO 6 SHAFTS
FOR UP TO 10 YEAR INSTALLATION LIFESPAN

DESCRIPTION	QUANTITY
• Resin mixing jars (10g)	6
• Curing agent 10 Bottle (15ml)	1
• Calibrated pipettes	6
• Stirring rods	6
• Silicon gum pad	1
• 1” reel of Mylar tape	1

Typical environmental protection

M Coat-F environmental protection kit

Available from Datum Electronics

DESCRIPTION	QUANTITY
• Self adhering Teflon tape	1
• Butyl pliable rubber sealant	1
• Neoprene rubber sheets	1
• Aluminium foil tape	1
• M-Coat B: Air drying nitrile rubber coating	1

Consumables kit required

DESCRIPTION	QUANTITY
• Ballpoint pen	1
• Industrial degreaser	1
• Cable ties	6
• Cleaning rags	1
• TCW 24 tined copper wire	1
• Masking tape or marker pen	1 roll
• Banding	kit

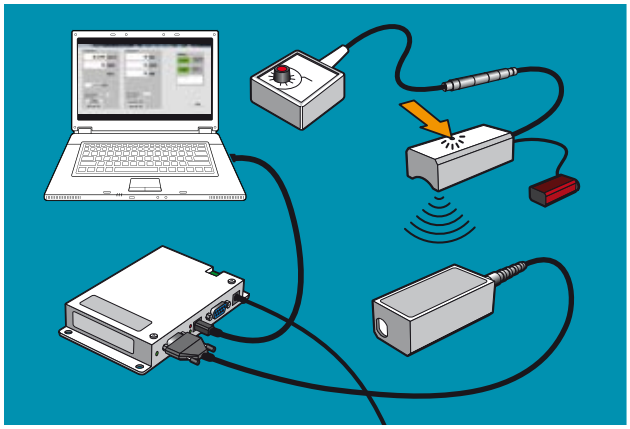
Tool kit required

DESCRIPTION	QUANTITY
• Dremel	1
• Angle marking bar	1
• Metric hex driver set	1
• Large flat head screw driver	1
• Side cutters	1
• Tin snips	1
• Tweezers	1
• Notebook PC with test software	1
• Small toughened glass plate for gauge preperation	1

EQUIPMENT PREPARATION

01

FAMILIARISE YOURSELF WITH THE SYSTEM



Testing of Transmitter and Receiver communications is vital before on-site installation commences.

Connect the interface module to the test computer with only the USB cable connected. Then install the Powerkit software and connect up the off shaft receiver and power the interface module. The red LED will show on the receiver to indicate it is working. Connect the battery to the on-shaft transmitter; the LED on top of the transmitter will blink several times to show it has power. Connect the strain gauge simulator to to the on-shaft transmitter and move the selector to the zero position.

The green LED on the off-shaft receiver should now show one green light indicating that the transmitter and receiver are connected and good data is being transmitted

Wave the speed reflector in front of the off shaft receiver's optical sensor and check that the green speed pulse LED lights to indicate the RPM counter is working correctly

Load the Powerkit software and correctly connect to the receiver/transmitter system. Once correctly connected move the strain gauge simulator through all the points and the onscreen torque value will change, wave the speed sensor in front of the off shaft receiver's optical sensor and the RPM figure will change. With no strain gauge connected the software will display approximately 3.26 mV/V.

Having completed this test you have tested the transmitter and your test receiver and gained a level of familiarity with the kit. The hardware and software checks are now complete.

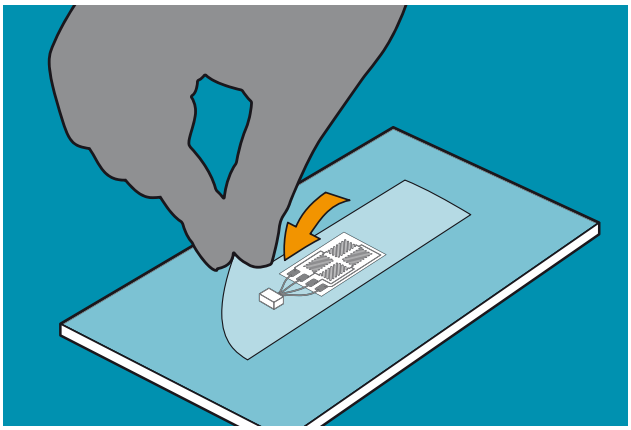
02

STRAIN GAUGE PREPARATION (GUIDANCE ONLY)

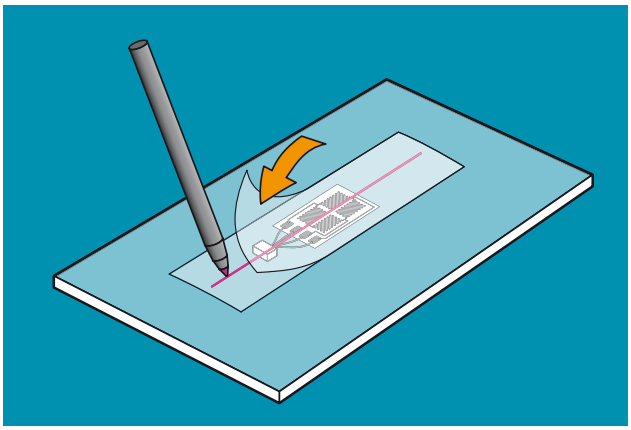
1. When mounting the strain gauge you will need to have prepared it on a glass plate with mylar tape. It is better to complete this stage in a clean room with good light before going on site.

   Thoroughly clean the surface of the glass plate using the M-Prep Conditioner first and then the M-Prep Neutraliser. This will ensure that the plate is chemically clean.

2. Using clean tweezers place the gauge on the plate with the solder/cable side uppermost. Familiarise yourself with the gauge element orientation using a magnifying glass.



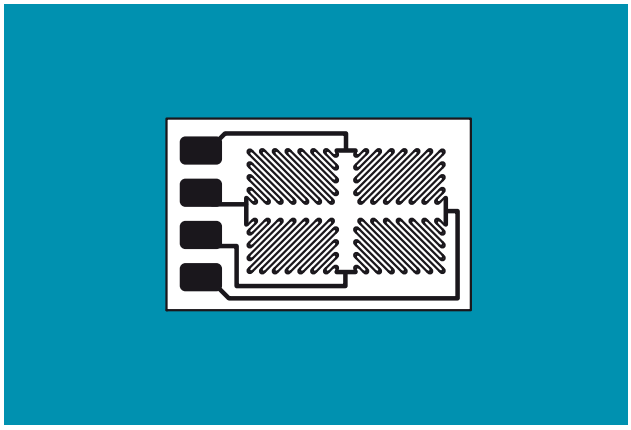
3. Cut a length of mylar tape approximately 150mm in length. Carefully offer the tape to the top side of the gauge and stick the gauge roughly in the centre of the mylar tape (see above). Stick the tape onto the glass plate with the gauge in a central position.



4. After applying the first layer of tape mark a line across the gauge (see above) using an indelible marker, parallel to the long side of the gauge. Then add a second layer of mylar tape. The second layer will stop the tape curling when applying the gauge to the shaft.

   Gently lift the two layers of tape away, with the gauge now stuck to it, ensuring that you always handle the tape and not the gauge itself.

   IF NO PREPARED CLEAN SURFACE IS AVAILABLE:
   Cut a strip of mylar tape approximately 150mm in length. Lay the tape on a flat clean surface so that the adhesive backing is facing upwards. Remove the gauge from its packaging using a pair of clean tweezers using the minimum pressure possible. Carefully place the strain gauge in the centre of the mylar tape. During all processes take great care to avoid contaminating the gauge or mylar tape.



The strain gauge supplied by Datum Electronics is a full bridge encapsulated gauge complete with a connector. These simplify the installation process and remove the need for soldering on site. The gauge has fine elements within its grid that measure strain. These elements can be seen under a magnifier and should be aligned at 45 degrees to the axis of the shaft to measure the torsional strain.

You should familiarise yourself with the gauge in a well lit environment before going to site where light may be limited.

STRAIN GAUGE PREPARATION IS NOW COMPLETE, YOU NOW NEED TO PREPARE THE SHAFT.

03

BATTERY TESTING

The PP3 9V battery should be new. Connect the battery to the Transmitter Enclosure using the supplied connectors. If the light on the top of the Transmitter Enclosure flashes, then the battery is fully charged. If the light does not flash, replace the battery with a new one.

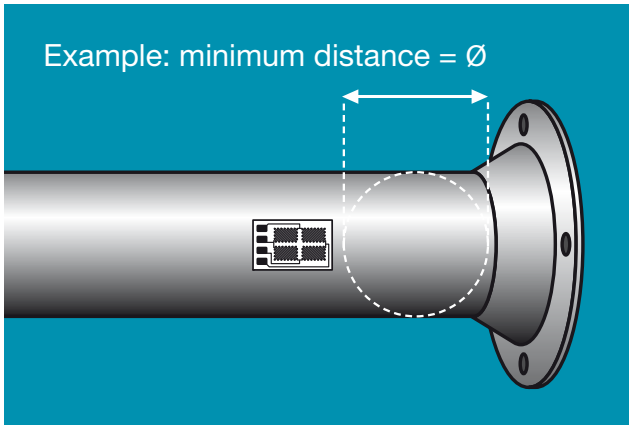
SHAFT PREPARATION

04

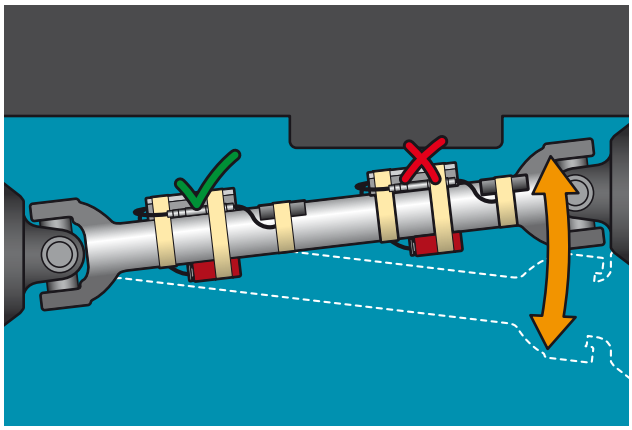
SELECTION OF INSTALLATION POSITION

The selection of a suitable area to be gauged on the drive shaft is vital to the success of the installation and data recovery. The area to be gauged should, where practicably possible, transmit the maximum level of torque/strain that is to be measured through the shaft.

1. The area should be large enough to mount the instrumentation. Look at the Transmitter unit to approximate the size of the clean gauging area that will be required.



2. Measure the diameter of the shaft. The gauging area should be no less than one shaft diameter away from any obstruction or shaft joint (see above).



3. There must not be any areas of interference once the instrumentation is mounted and the shaft is rotating. Changes in pitch/travel of the shaft during normal operation should be taken into account, with the instrumentation mounted clear of any obstructions caused by shaft pitch/travel (see above). If the instrumentation is mounted on a vehicle suspension, travel should also be accounted for.
4. If measuring shaft speed (and power) you will need to mount the receiver so that it can be directed at the shaft.
5. There should be sufficient hand and working access to enable installation of the equipment and fitting of the battery.
6. Avoid any section of the shaft that contains major pitting or excessively deep scratches.
7. Offer the complete Transmitter Assembly up to the chosen area to check clearance and also check for any rotational interferences.

Full guidance is supplied with the adhesives and cleaner preparation chemicals.

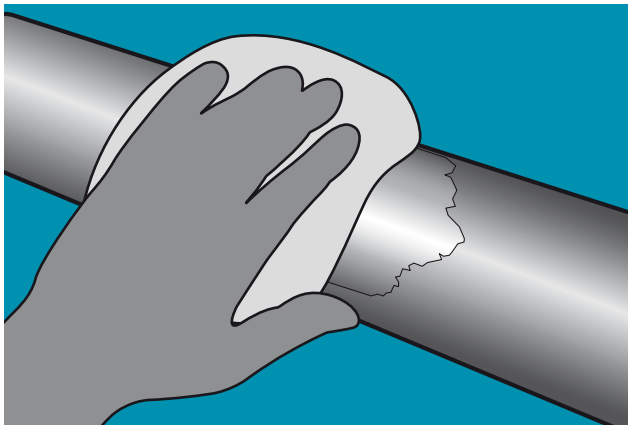
05

SURFACE PREPARATION (GUIDANCE ONLY)

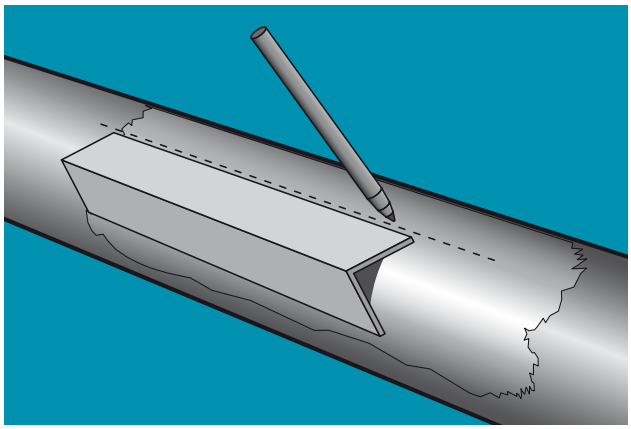
Once the installation position has been determined it is time to prepare the strain gauge area. Correct preparation of surfaces to be gauged is essential for successful equipment installation and data collection.

It is recommended that the chosen area of drive shaft is thoroughly cleaned and degreased prior to commencing strain gauging in order to prevent contaminating the gauge area.

BASIC CLEANING PREPARATION



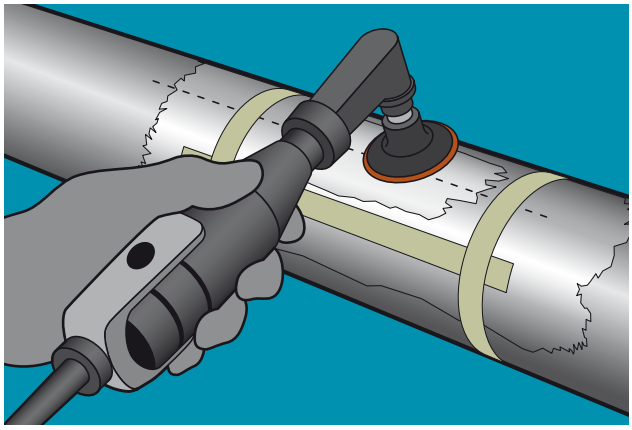
1. Clean the chosen area using rags and industrial cleaner/degreaser (see above). Remove as much dirt and grease as possible.
2. Clean area again. Once area is clean commence marking out following the steps below.



3. Place the angled bar flush to the shaft, and mark a line parallel to the shaft using a ball point pen (see above). This will act as a burnished line positioning guide to the centre line you marked on the mylar tape over the gauge in Stage 1.4.

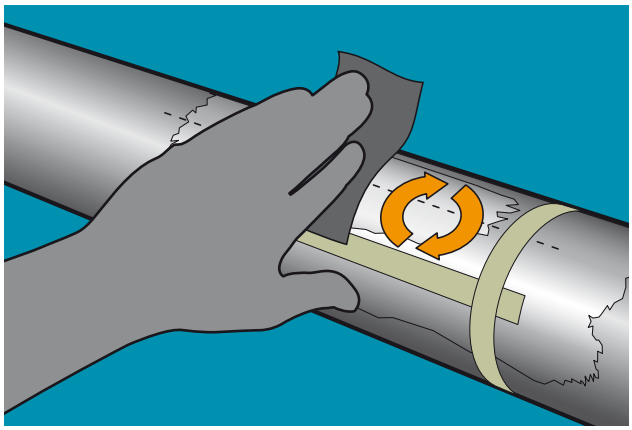
SURFACE ABRADING

The surface of the drive shaft should be abraded to remove any loosely bonded adherents such as scale, rust, paint, galvanised coatings or oxides.



4. Using the Transmitter unit as a guide, roughly indicate the area to be cleaned using masking tape (see above).

   Begin with a grinder, Dremel, disc sander or file to coarsely abrade the surface and remove any large particles such as paint, rust or any other adherents (see above). Abrade with 80-120 grit abrasive to develop a surface texture suitable for bonding.



5. Second stage abrading uses silicon carbon paper of the appropriate grit. It is recommended that abrading should start at 120 grit progressing through to 400 grit in a random pattern to attain a flat, clean, and well keyed surface (see above).

   The optimum surface finish for gauge bonding depends somewhat upon the nature and purpose of the installation. For general stress analysis applications, a relatively smooth surface is suitable.

WET ABRADING

Wet abrading is carried out using a conditioner solution. Conditioner is a mildly acidic solution which generally accelerates the cleaning process and, on some materials, acts as a gentle etchant.

6. Carry out final abrading with 400 grit paper while keeping the surface wet with conditioner solution. Use a random pattern to attain a flat, clean, and well keyed surface.

   Following cleaning the burnished line should still be visible. If working in poor light mark reference lines either side of the gauge markings to draw the eye to the burnished lines.

GAUGE LOCATION LAYOUT LINES

Gauge location layout lines should be made with a tool which burnishes, rather than scores or scribes, the surface. A scribed or scored line may raise a burr or create a stress concentration detrimental to strain gauge performance.

It is recommended that ballpoint pen is used for making alignment markings. Layout lines are ordinarily applied following the abrading operation and before final cleaning. All residues from the location marking operation should be removed by scrubbing with conditioner, as described in Stage 9 of the Surface Preparation process.

7. Mark out strain gauge location lines on the centre line you marked in step 05.3.
8. All masking tape can now be removed from the drive shaft.

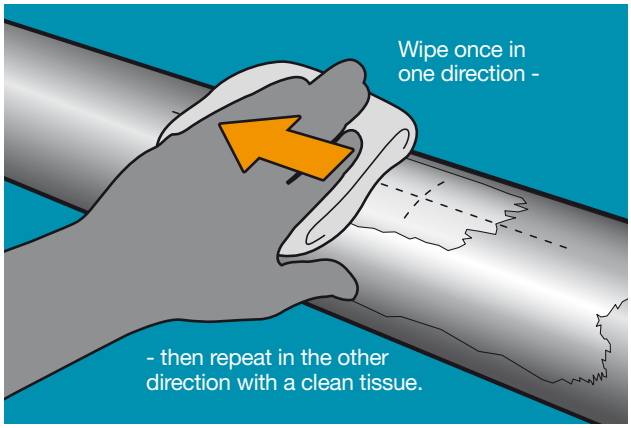
SURFACE CONDITIONING

9. Repeatedly apply conditioner and scrub the surface with cotton tipped applicators until a clean tip is no longer discoloured by the scrubbing. During this process the surface should be kept constantly wet with the conditioner until cleaning is completed. Cleaning solutions should never be allowed to dry on the surface.
10. When clean, the surface should be dried by wiping across the cleaned area with a single slow stroke of a lint free tissue. The stroke should begin from well within the cleaned area and move outwards to avoid dragging contaminants in from the boundary of the area using each tissue one only.

NEUTRALISING

The final step in surface preparation is to bring the surface condition back to an optimum alkalinity of 7.0 to 7.5 pH, which is suitable for all strain gauge adhesive systems.

11. Liberally apply neutraliser to the cleaned surface and scrub the surface with a cotton tipped applicator. The cleaned surface should be kept completely wet with neutraliser throughout this operation.



12. When neutralised, the surface should be dried by wiping across the cleaned area with a single slow stroke of a clean lint-free tissue. With a fresh lint-free tissue, a single stroke should then be made in the opposite direction, beginning within the cleaned area and moving outwards to avoid recontamination from the uncleaned boundary (see above).

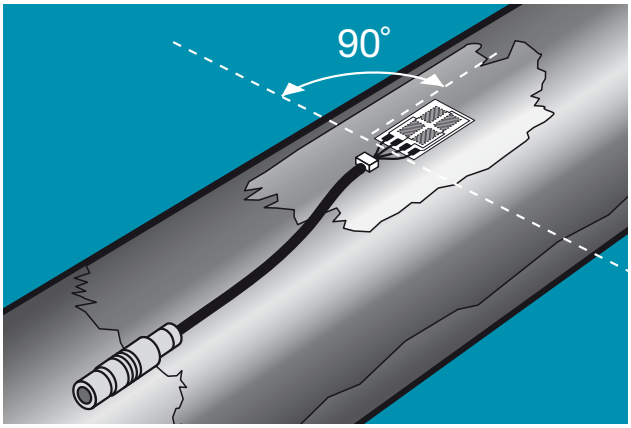
The surface is now properly prepared for gauge bonding. Gauges should be installed **as soon as possible** after this operation to prvent contamination.

PREPARATION IS NOW COMPLETE

INSTALLATION

06

GAUGE APPLICATION



You are now ready for strain gauge application.

The strain gauge supplied for this application is manufactured by Vishay Micro-Measurements Group to Datum specifications. The standard procedures for Vishay strain gauge application are described in Appendices 1 and 2 of this document.

Additional information regarding alterative adhesives can be found at: **http://www.vishaymg.co.uk/adhesives.htm**

1. The strain gauge is bonded to the shaft using one of two procedures.

   ### PROCEDURE A - Trials application

   This is recommended for short trials of 3 months in duration and where time on-site is limited. This procedure utilises a cyanoacrylate adhesive (M-Bond 200) that will cure in approximately 60 seconds by thumb pressure.

   PROCEDURE A IS LISTED IN DETAIL IN **APPENDIX 1** OF THIS DOCUMENT. THE INSTRUCTIONS IN THIS APPENDIX MUST BE FOLLOWED BEFORE MOVING TO THE NEXT STAGE.

   ### PROCEDURE B - Permanent application

   This is recommended for longer term installations where strain gauges will need operate for up to 10 years or more. This procedure utilises a two part epoxy adhesive that cures in six hours at 20˚C, reducing to one hour at 60˚C. The gauge is held by a pressure pad while curing.

   PROCEDURE B IS LISTED IN DETAIL IN **APPENDIX 2** OF THIS DOCUMENT. THE INSTRUCTIONS IN THIS APPENDIX MUST BE FOLLOWED BEFORE MOVING TO THE NEXT STAGE.

Protection from the environmental

Both strain gauge installation methods require that coatings are applied to insure that no moisture or other contamination reaches the strain gauge or the exposed wiring. The level of coatings applied will vary according to the operating conditions and the duration of the testing.

2. **After applying the strain gauge as described in the Appendices,** the gauge should be visually inspected to check that the bonds are secure, and that there are no significant air bubbles or inclusions present under the strain gauge.

The gauge, once bonded, will have an usually display a signal offset due to the distortion of the gauge around the radius and also by the action of applying hand pressure during the bonding process. The level of offset will vary from installation to installation. The offset of the gauge can be measured using a PC connected to the Receiver running the software utility. The output of the gauge, and hence the offset, will be shown in mV/V. Typically this reading will be +/-0.000mV/V to +/-0.500mV/V, the instrumentation being designed to cater for an offset of up to 1.000mV/V. If the offset is greater than this value the installation is likely to be faulty. This may be caused by an uneven or twisting pressure at installation. If the gauge offset is greater than 1.0mV/V you will need to replace the gauge. Clean the area and repeat the gauge installation.

Alternatively, this offset can be measured using a gauge indicator of some description.

3. Once the gauge is installed, and with either a handheld indicator or PC connected, you should if possible apply a twist to the shaft. Applying a small torque to the shaft by hand or by a manual lever is usually sufficient to allow you to see the readings on the display change. By applying a small force in this way you are able to gain additional confidence in your strain gauge installation.

   The value should increase/decrease slightly and then return to the start value as the twist is released (see above).

   Note the value for the gauge with no load at this stage as this will be required for future testing and diagnostics.

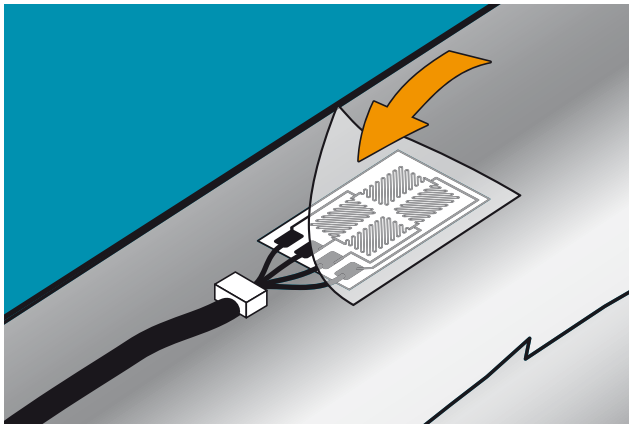
STRAIN GAUGE INSTALLATION IS NOW COMPLETE

07

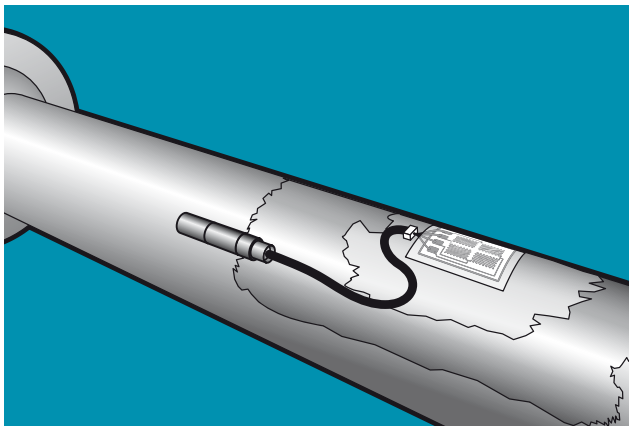
PROTECTION OF THE STRAIN GAUGE

The protection of strain gauges is vital in order to maintain good strain readings.

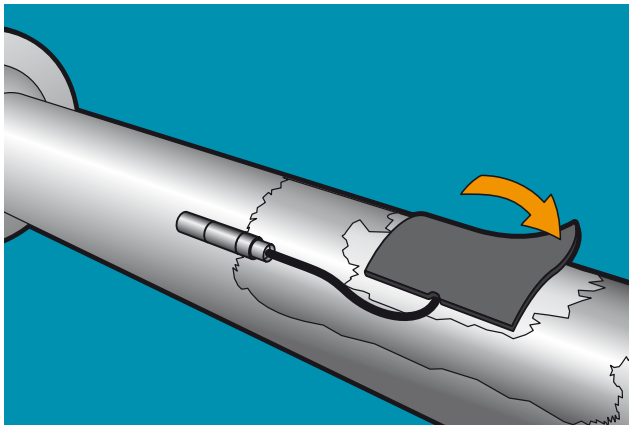
Excessive moisture or ingress of other fluids may cause a strain gauge to drift, resulting in poor or unrealistic readings. When encapsulated strain gauges are being used the following process offers a suitable level of protection.



1. Cut a piece of Teflon tape (approx 30mm long) to cover the gauge and the connector, and stick it over the strain gauge onto the cleaned area where the strain gauge is bonded to the shaft.



2. Apply pressure to the edges of the Teflon tape to provide a good seal around the gauge.

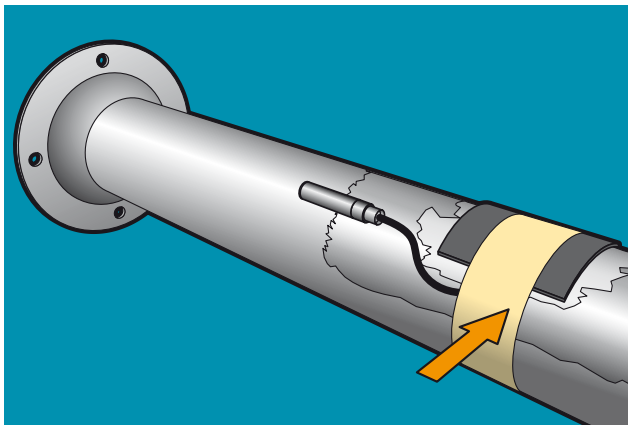


3. Cut a strip of butyl mastic large enough to cover the strain gauge and the area of Teflon, and stick over gauge onto the cleaned area where the strain gauge is bonded to the shaft (see above). Apply pressure to the edges of the mastic to provide a good seal around the gauging area but leave the cable exposed.

The shaft area needs to be chemically clean for the mastic to adhere - warming the mastic to 25-30˚C will also assist with fitting and adhesion.

Additional information regarding strain gauge coating options can be found at:

http://www.vishaymg.co.uk/protective_coatings.htm



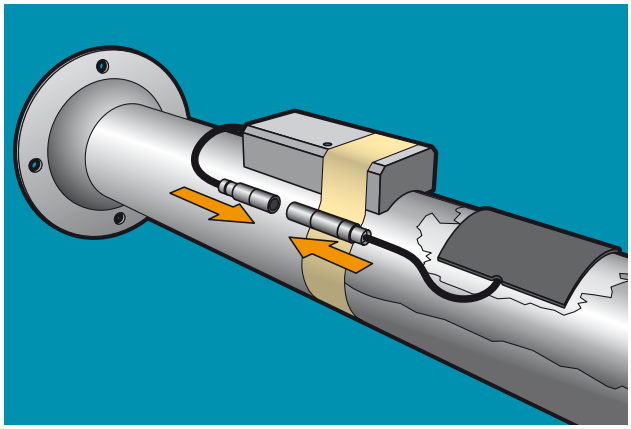
4. At higher revolutions additional layers of cross weave tape should be used to secure the mastic coatings. Suitable tapes to use are either Strong Cross Weave Tape or and Adhesive Glass Cloth Tape with a strength in excess of 25kgs per cm.

PROTECTION OF STRAIN GAUGE IS NOW COMPLETE

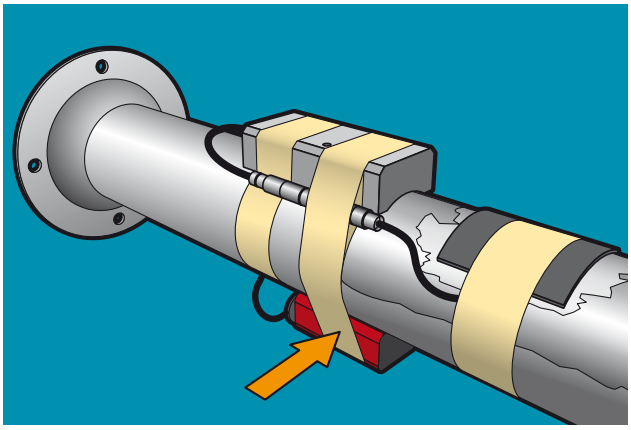
08

TRANSMITTER INSTALLATION

1. Place the Transmitter Enclosure close to the protected gauge area ensuring that the gauge cable does not become trapped in any way and allowing enough cable to plug the gauge connector to the Transmitter Enclosure. Secure the Transmitter Enclosure in place by taping to the shaft with four wraps of the cross weave tape. Take care not to cover the LED.



2. Plug the strain gauge connector into Transmitter connector. Wrap excess cable around Transmitter Enclosure.



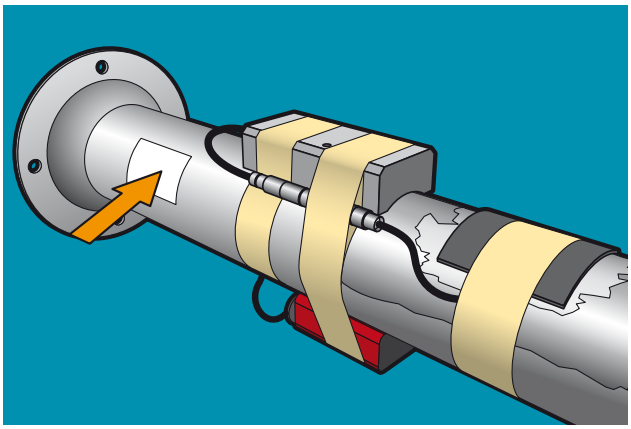
3. Position the battery on the shaft at 180deg to the transmitter on shaft up to 100mm to improve shaft balance.
4. Secure the battery in place by taping it to the shaft. Tape around the shaft and over the Transmitter Enclosure, battery and Transmitter connectors, securely fixing them all to the shaft (see above).

TRANSMITTER INSTALLATION IS NOW COMPLETE

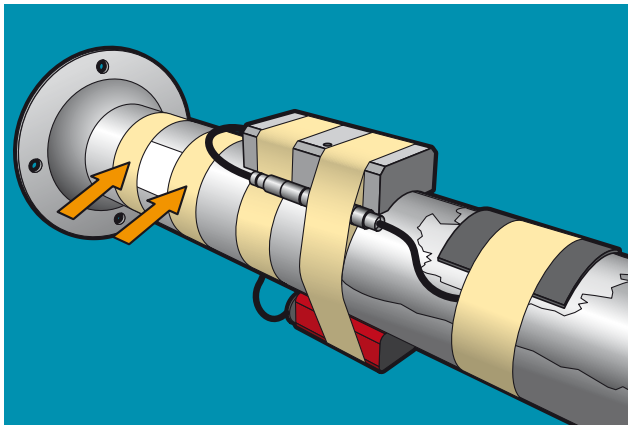
09

MEASURING RPM AND POWER – SPEED REFLECTOR INSTALLATION

1. The reflective tape that forms the target for the Optical Proximity Sensor should be positioned on the shaft so that the optical Receiver Module can be aimed at it. The Receiver Module's optical beam should be perpendicular to the sensor to ensure a good reflected signal. Avoid positioning the tape next to other highly reflective structures or surfaces that might reflect a false signal once the shaft is rotating.



2. Cut a piece of reflective tape approximately 30mm x 100mm and position it on the shaft.



3. Hold it in place by wrapping tape around the shaft at each end of the reflective tape.

SPEED REFLECTOR INSTALLATION IS NOW COMPLETE

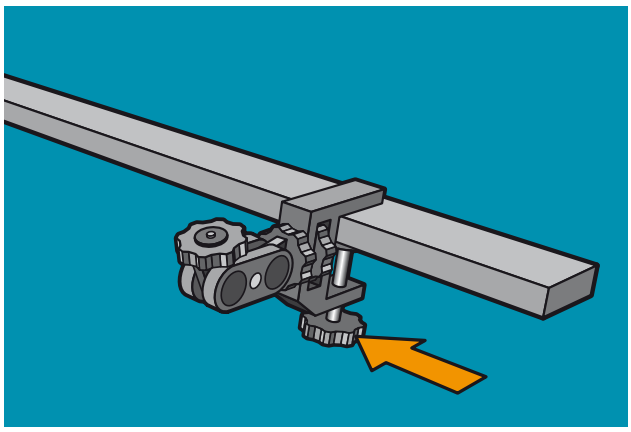
10

RECEIVER INSTALLATION

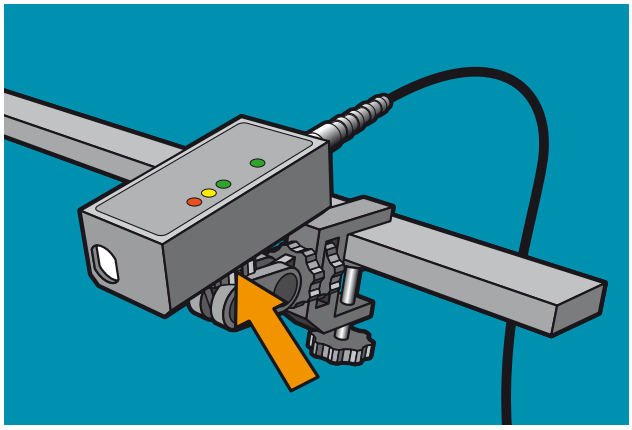
If measuring RPM/Power locate a suitable structure to mount the Receiver Module to, that also allows the receiver's speed sensor to be aligned to the Transmitter.

If only measuring torque the receiver needs to be located within 3 meter line of sight to the transmitter location but its directional alignment is not critical.

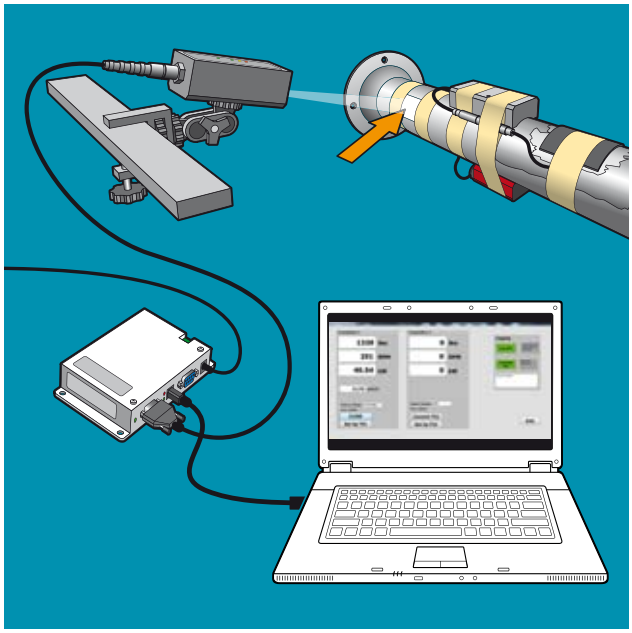
The Optical Speed Sensor on the Receiver Module should be aligned perpendicular to the reflector on the shaft to ensure the beam is reflected back to the Receiver and metered correctly.



1. Attach the Receiver Mounting Clamp to the suitable structure and tighten the locking wheels (see above).



2. Attach the Receiver Module to the Receiver Mounting Clamp by screwing it to the mounting thread and firmly tighten the locking wheel.
3. Position the optical sensor to aim at the reflector on the shaft by adjusting the locking wheels as required. Tighten all the locking wheels on the Receiver Mounting Clamp firmly.
4. Connect the Receiver Module to the Interface Unit using the 10 metre cable supplied. The cable has a RS232 connector for the Interface Unit and a connector for the Receiver. Optional extension cables are available on request.



The cable run from the Receiver to the Interface should be secured approximately every 0.5 metres so as not to become a hazard. IMPORTANT NOTE: When running cable ensure that it is not mounted in any area that may become damaged by the moving or rotational machinery. Coil up and securely tie any excess cable.

For multi-shaft installation we can provide transmitters with unique transmission channels and a multi-channel PC interface/power supply.

RECEIVER INSTALLATION IS NOW COMPLETE

APPENDIX 01

UNDERSTANDING THE RECEIVER LEDs

Understanding the LED's on Datum's 2.4GHz radio based Torque Meters and help diagnosing communication problems.

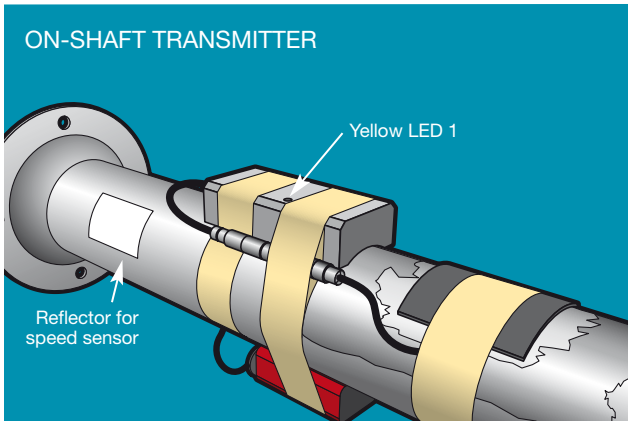
ON-SHAFT TRANSMITTER

The on-shaft transmitter has only one LED.

YELLOW LED: This LED will flash fast for up to 3 seconds whilst trying to connect to the receiver when the battery is connected.

When the transmitter has connected to the receiver, the Yellow LED will flash once a sample has been acquired, this is 10 times a seconds for the standard sample rate of 10 SPS.

If the transmitter cannot connect to the receiver the Yellow LED will flash briefly once every three seconds (power saving mode). If this happens, check the status of the off-shaft receiver LED's (oposite), check that power is supplied to the off-shaft receiver, the equipment that supplies power to the off-shaft receiver is powered on etc.



OFF-SHAFT RECEIVER

The Receiver has four LED's.

RED LED 1: Is illuminated if no data has been received from the transmitter for more than 2 seconds. It is extinguished as soon as data is received.

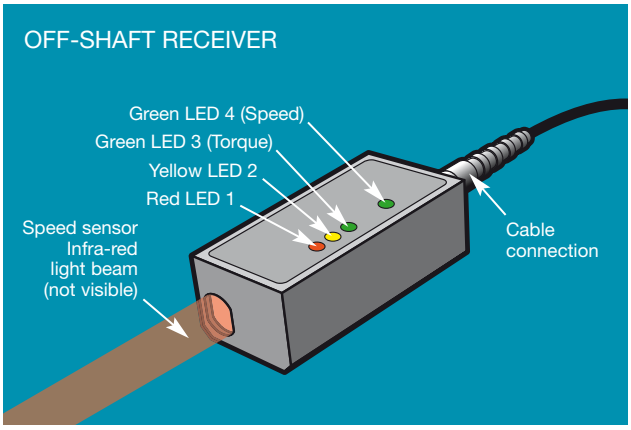
YELLOW LED 2: Flashes if data is not received when expected. It will continue to flash as long as no data is received for a period of approximately 2 seconds, after which after which it will be extinguished and the Red LED will illuminate. If data is received the Yellow LED will be extinguished.

GREEN LED 3 (Torque): Flashes briefly every time data is received from the on-shaft transmitter. In normal operation this will flash approximately 5 times per seconds, indicating reception of continuous data. Reception of data is only an indication of the integrity of the data transmission between the on-shaft transmitter and the off-shaft receiver; it does not convey any indication of the accuracy of the data received.

If no LED's are visible, check that power is supplied to the off-shaft receiver, the equipment that supplies power to the off-shaft receiver is powered on. Ensure that the circular connector to the off-shaft receiver is screwed in tight, no cables are damaged and in-line fuses are correct. Try power cycling the off-shaft receiver (undo the circular connect remove for a moment and reconnect, look at the LED's and confirm the correct operation as above.

Note: Ensure that the on-shaft transmitters Yellow LED is flashing before power cycling the off-shaft receiver to ascertain that a connection can be made.

GREN LED 4 (Speed) is illuminated whenever the speed sensor senses the reflective material on the power band segment. As such, it should flash once per revolution when the shaft is rotating.



APPENDIX 02

PROCEDURE A: STRAIN GAUGE INSTALLATION FOR SHORT TERM USAGE

THE STRAIN GAUGES SUPPLIED ARE MANUFACTURED BY **VISHAY MICRO-MEASUREMENTS GROUP** TO DATUM SPECIFICATIONS.

SHOULD MATERIALS SPECIFIED NOT BE AVAILABLE, OR THERE ARE PROCESSES WHICH REQUIRE CLARIFICATION, CONTACT YOUR **LOCAL VISHAY OFFICE** FOR ADVICE AND RECOMMENDATIONS.

INTRODUCTION

Micro-Measurements Certified M-Bond 200 is an excellent general-purpose laboratory adhesive because of its fast room-temperature cure and ease of application.

When properly handled and used with the appropriate strain gauge, M-Bond 200 can be used for high-elongation tests in excess of 60 000 microstrain, for fatigue studies, and for one-cycle proof tests to over +200 °F [+95 °C] or below -300 °F [-185°C]. The normal operating temperature range is -25° to +150°F [-30° to +65°C]. MBond 200 is compatible with all Micro-Measurements strain gauges and most common structural materials.

When bonding to plastics, it should be noted that for best performance the adhesive flowout should be kept to a minimum. For best reliability, it should be applied to surfaces between the temperatures of +70° and +85°F [+20° to +30°C], and in a relative humidity environment of 30% to 65%.

M-Bond 200 catalyst has been specially formulated to control the reactivity rate of this adhesive. The catalyst should be used sparingly for best results. Excessive catalyst can contribute many problems; e.g., poor bond strength, age-embrittlement of the adhesive, poor glueline thickness control, extended solvent evaporation time requirements, etc.

Since M-Bond 200 bonds are weakened by exposure to high humidity, adequate protective coatings are essential.

This adhesive will gradually become harder and more brittle with time, particularly if exposed to elevated temperatures. For these reasons, M-Bond 200 is not generally recommended for installations exceeding one or two years.

For proper results, the procedures and techniques presented here should be used with qualified Micro- Measurements installation accessory products (refer to Catalog A-110). Those used in this procedure are:

- CSM Degreaser or GC-6 Isopropyl Alcohol
- Silicon Carbide Paper
- M-Prep Conditioner A
- M-Prep Neutraliser 5A
- GSP-1 Gauze Sponges
- CSP-1 Cotton Applicators
- PCT- 2M Gauge Installation Tape

SHELF AND STORAGE LIFE

M-Bond 200 adhesive has a minimum shelf life of three months at +75°F [+24°C] after opening and with the cap placed back onto the bottle immediately after each use.

NOTE: To ensure the cap provides a proper seal, the bottle spout should be wiped clean and dry before replacing the cap.

Unopened M-Bond 200 adhesive may be stored up to three months at +75°F [+24°C] or six months at +40°F [+5°C].

HANDLING PRECAUTIONS

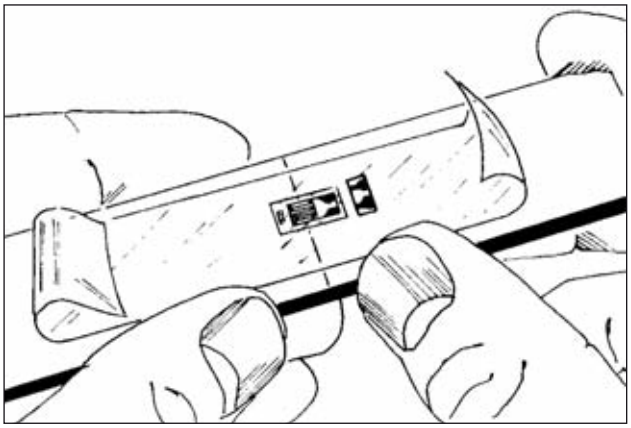
M-Bond 200 is a modified alkyl cyanoacrylate compound. Immediate bonding of eye, skin or mouth may result upon contact. Causes irritation. The user is cautioned to: (1) avoid contact with skin; (2) avoid prolonged or repeated breathing of vapors; and (3) use with adequate ventilation. For additional health and safety information, consult the Material Safety Data Sheet, which is available upon request.

NOTE: Condensation will rapidly degrade adhesive performance and shelf life; after refrigeration the adhesive must be allowed to reach room temperature before opening, and refrigeration after opening is not recommended.

GAUGE APPLICATION TECHNIQUE

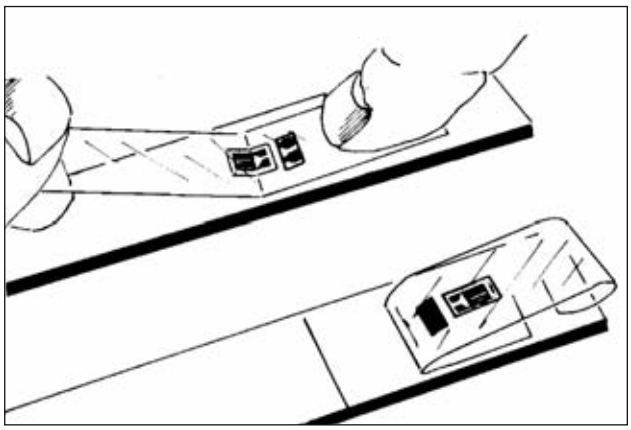
The installation procedure presented on the following pages is somewhat abbreviated and is intended only as a guide in achieving proper gauge installation with M-Bond 200. Micro-Measurements Application Note B-129 presents recommended procedures for surface preparation, and lists specific considerations which are helpful when working with most common structural materials.

STEP 01



Position the gauge/tape assembly so that the triangle alignment marks on the gauge are over the layout lines on the specimen. If the assembly appears to be misaligned, lift one end of the tape at a shallow angle until the assembly is free of the specimen. Realign properly, and firmly anchor at least one end of the tape to the specimen. Realignment can be done without fear of contamination by the tape mastic if Micro-Measurements PCT-2M gauge installation tape is used, because this tape will retain its mastic when removed.

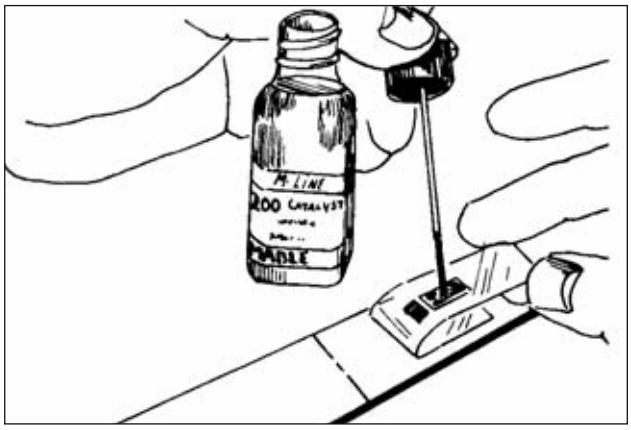
STEP 02



Lift the gauge end of the tape assembly at a shallow angle to the specimen surface (about 45 degrees) until the gauge and terminal are free of the specimen surface. Continue lifting the tape until it is free from the specimen approximately 1/2 in [10 mm] beyond the terminal. Tuck the loose end of the tape under and press to the specimen surface so that the gauge and terminal lie flat, with the bonding surface exposed.

NOTE: Micro-Measurements gauges have been treated for optimum bonding conditions and require no pre-cleaning before use unless contaminated during handling. If contaminated, the back of any gauge can be cleaned with a cotton-tipped applicator slightly moistened with M-Prep Neutraliser 5A.

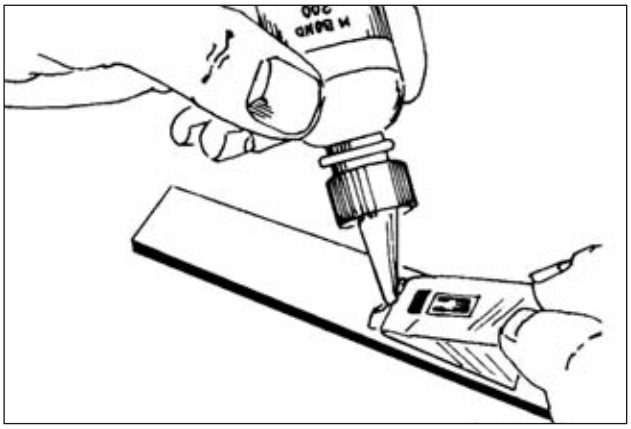
STEP 03



M-Bond 200 catalyst can now be applied to the bonding surface of the gauge and terminal. M-Bond 200 adhesive will harden without the catalyst, but less quickly and reliably. Very little catalyst is needed, and it should be applied in a thin, uniform coat. Lift the brush-cap out of the catalyst bottle and wipe the brush approximately 10 strokes against the inside of the neck of the bottle to wring out most of the catalyst. Set the brush down on the gauge and swab the gauge backing. Do not stroke the brush in a painting style, but slide the brush over the entire gauge surface and then the terminal. Move the brush to the adjacent tape area prior to lifting from the surface. Allow the catalyst to dry at least one minute under normal ambient conditions of +75°F [+24°C] and 30% to 65% relative humidity before proceeding.

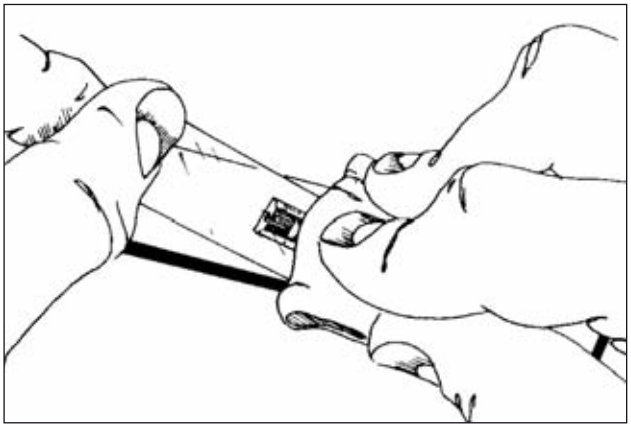
NOTE: **THE NEXT THREE STEPS MUST BE COMPLETED IN THE SEQUENCE SHOWN, WITHIN 3 TO 5 SECONDS. READ STEPS 8, 9, AND 10 BEFORE PROCEEDING.**

STEP 04



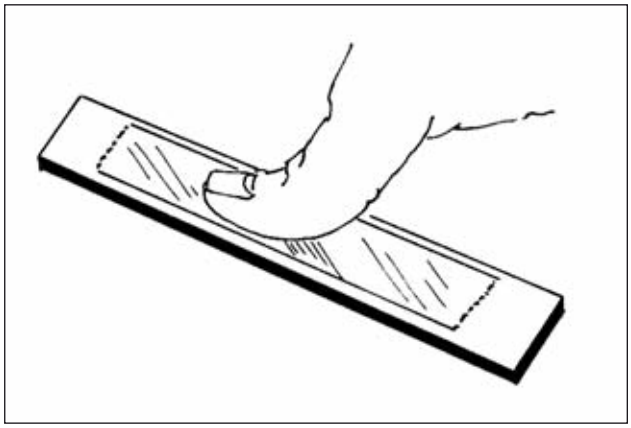
Lift the tucked-under tape end of the assembly, and, holding in the same position, apply one or two drops of MBond 200 adhesive at the fold formed by the junction of the tape and specimen surface. This adhesive application should be approximately 1/2 in [13 mm] outside the actual gauge installation area. This will insure that local polymerization that takes place when the adhesive comes in contact with the specimen surface will not cause unevenness in the gauge glueline.

STEP 05



Immediately rotate the tape to approximately a 30-degree angle so that the gauge is bridged over the installation area. While holding the tape slightly taut, slowly and firmly make a single wiping stroke over the gauge/tape assembly with a piece of gauze bringing the gauge back down over the alignment marks on the specimen. Use a firm pressure with your fingers when wiping over the gauge. A very thin, uniform layer of adhesive is desired for optimum bond performance.

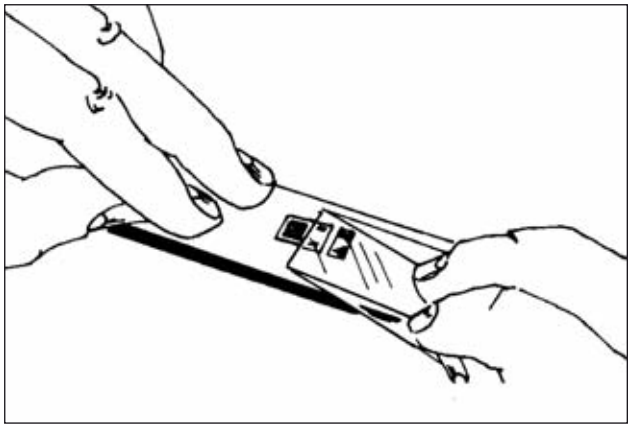
STEP 06



Immediately upon completion of wipe-out of the adhesive, firm thumb pressure must be applied to the gauge and terminal area. This pressure should be held for at least one minute. In low-humidity conditions (below 30%), or if the ambient temperature is below +70°F [+20°C], this pressure application time may have to be extended to several minutes.

Where large gauges are involved, or where curved surfaces such as fillets are encountered, it may be advantageous to use preformed pressure padding during the operation. Pressure-application time should again be extended due to the lack of "thumb heat" which helps to speed adhesive polymerization. Wait two minutes before removing tape.

STEP 07



The gauge and terminal strip are now solidly bonded in place. It is not necessary to remove the tape immediately after gauge installation. The tape will offer mechanical protection for the grid surface and may be left in place until it is removed for gauge wiring. To remove the tape, pull it back directly over itself, peeling it slowly and steadily off the surface. This technique will prevent possible lifting of the foil on open-faced gauges or other damage to the installation.

ONCE **PROCEDURE A** IS COMPLETE, PROCEED TO **SECTION 07.2** OF THIS MANUAL TO CONTINUE THE STRAIN GAUGING PROCESS.

APPENDIX 03

PROCEDURE B: STRAIN GAUGE INSTALLATION FOR LONG TERM USAGE

THE STRAIN GAUGES SUPPLIED ARE MANUFACTURED BY **VISHAY MICRO-MEASUREMENTS GROUP** TO DATUM SPECIFICATIONS.

SHOULD MATERIALS SPECIFIED NOT BE AVAILABLE, OR THERE ARE PROCESSES WHICH REQUIRE CLARIFICATION, CONTACT YOUR **LOCAL VISHAY OFFICE** FOR ADVICE AND RECOMMENDATIONS.

INTRODUCTION

The three adhesives described in this bulletin, M-Bond AE- 10, AE-15, and GA-2, are all 100%-solids epoxy systems for use with strain gauges and special-purpose sensors. The gauge installation procedure described is appropriate for each adhesive, the primary differences in the systems being in mixing instructions, pot life, cure cycles, and, to some extent, elongation properties. Each system is effective from the cryogenic region to +200°F [+95°C].

For proper results, the procedures and techniques presented in this bulletin should be used with qualified Micro-Measurements installation accessory products (refer to Micro-Measurements Accessories Catalog A-110). Accessories used in this procedure are:

- CSM Degreaser or GC-6 Isopropyl Alcohol
- CSP-1 Cotton Applicators
- PCT-2M Gauge Installation Tape
- Silicon-Carbide Paper
- MJG-2 Mylar Tape
- M-Prep Conditioner A
- HSC Spring Clamp
- M-Prep Neutraliser 5A
- GT-14 Pads and Backup Plate
- GSP-1 Gauze Sponges

HANDLING PRECAUTIONS

While these bonding agents are considered relatively safe to handle, contact with skin and inhalation of their vapors should be avoided. Immediate washing with ordinary soap and water is effective in cleansing should skin contact occur. For eye contact, rinse thoroughly with a copious amount of water and consult a physician. For additional health and safety information, consult the material safety data sheet, which is available upon request.

MIXING INSTRUCTIONS AND ADHESIVE CHARACTERISTICS

A. GENERAL

1. Each kit contains materials for mixing six batches of adhesive. Mixing instructions for M-Bond AE-10 and MBond AE-15 Bulk are included below.
2. Any resin removed from refrigeration must be allowed attain room-temperature equilibrium before being opened.
3. Mix adhesives thoroughly for five minutes according to instructions. If a room-temperature cure is used, allow the freshly mixed adhesive to stand an additional five minutes before use.
4. The pot life for Systems AE-10 and GA-2 can be prolonged by occasionally stirring to prevent localised exotherm in the center of the resin system, or by pouring it out onto a chemically clean metal plate.

NOTE: During storage, crystals may form in the Resin AE. These crystals do not affect adhesive performance, but should be reliquefied prior to mixing by warming the resin jar to +120°F [+50°C] for approximately one-half hour. Allow the resin to return to room temperature before adding curing agent; excess heat will shorten mixed pot life.

B. M-BOND AE-10 ADHESIVE KIT

AE-10 will cure at +70°F [+20°C] in 6 hours, with approximately 6% elongation capability and essentially creep-free performance. Elongation capability of approximately 10% can be obtained by extending the cure time to 24 to 48 hours at +75°F [+24°C].* To mix, fill one of the calibrated droppers with Curing Agent 10 exactly to the number 10 and dispense the contents into the center of the jar of Resin AE. Immediately cap the bottle of Curing Agent 10 to avoid moisture absorption.

Mix thoroughly for 5 minutes, using one of the plastic stirring rods. The pot life or working time after mixing is 15 to 20 minutes. Discard the dropper after use. M-Bond AE-10 Bulk is packaged with 200 grams of resin, 40 grams of Curing Agent 10, and three calibrated pipettes. The mix ratio is 10.0 parts by weight of AE

Resin to 1.5 parts by weight of Curing Agent 10. Mix thoroughly for five minutes, then allow the mixture to stand for an additional five minutes before use. When mixing quantities greater than 10 grams of AE Resin, the normal pot life of 15-20 minutes will be shortened accordingly.

*Refer to Application Notes B-129 and TT-605 for discussions of high-elongation strain measurements.

C. M-BOND AE-15 ADHESIVE KIT

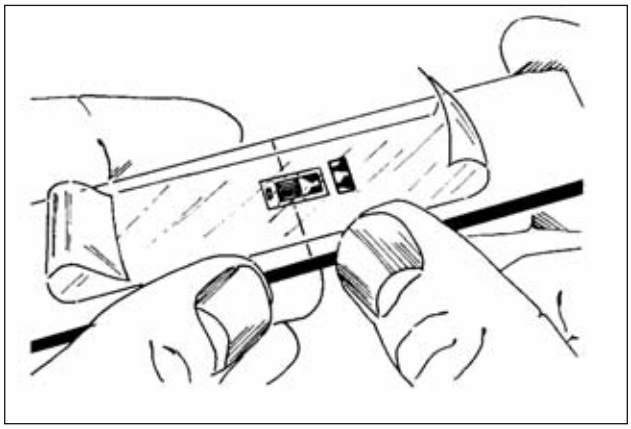
AE-15 requires moderately elevated curing temperatures, and is recommended for critical installations, such as strain gauge transducers, where zero shift and hysteresis must be minimised. The AE-15 system is also useful with high elongation strain gauges at strain levels up to approximately 10% to 15% at +70°F [+20°C], and at strain levels up to 15% at

+200°F [+95°C]. To mix, fill one of the calibrated droppers with Curing Agent 15 exactly to the number 15 and dispense the contents into the center of the jar of Resin AE. Immediately cap the bottle of Curing Agent 15 to avoid moisture absorption. Mix the Resin AE and the Curing Agent 15 thoroughly for 5 minutes, using one of the plastic stirring rods. The pot life is approximately 1-1/2 hours at +70°F [+20°C]. Discard the dropper after use. M-Bond AE-15 Bulk is packaged with 200 grams of resin, 25 grams of Curing Agent 15, and three calibrated pipettes. The mix ratio is 10.0 parts by weight of AE Resin to 0.8 parts by weight of Curing Agent 15. Mix thoroughly for five minutes, then allow the mixture to stand for an additional five minutes before use. When mixing quantities greater than 10 grams of AE Resin, the normal pot life of 15-20 minutes will be shortened accordingly.

D. M-BOND GA-2 KIT

GA-2 is a partially filled 100%-solids epoxy adhesive. Resin GA-2 with Hardener 10-A will have approximately 10% to 15% elongation capabilities when cured for 40 hours at +70°F [+20°C], and approximately 6% elongation capabilities when cured for 6 hours at +70°F [+20°C]. To mix, fill one of the calibrated droppers with Hardener 10-A exactly to the number 10, and dispense the contents into the jar of Resin GA-2. Immediately cap the bottle of Hardener 10-A to prevent moisture absorption. Mix the Resin GA-2 and the Hardener 10-A thoroughly for 5 minutes using one of the plastic stirring rods. Pot life is approximately 15 minutes at +70°F [+20°C]. Discard the dropper after use.

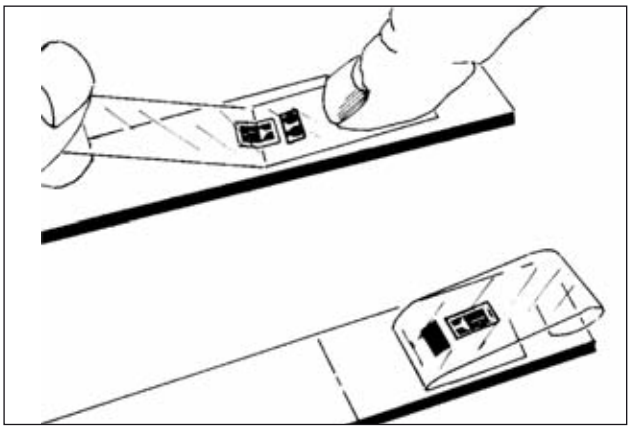
STEP 01



Position the gauge/tape assembly so the triangle alignment marks on the gauge are over the layout lines on the specimen. Holding the tape at a shallow angle, wipe the assembly onto the specimen surface. If the assembly appears to be misaligned, lift one end of the tape at a shallow angle until the assembly is free of the specimen.

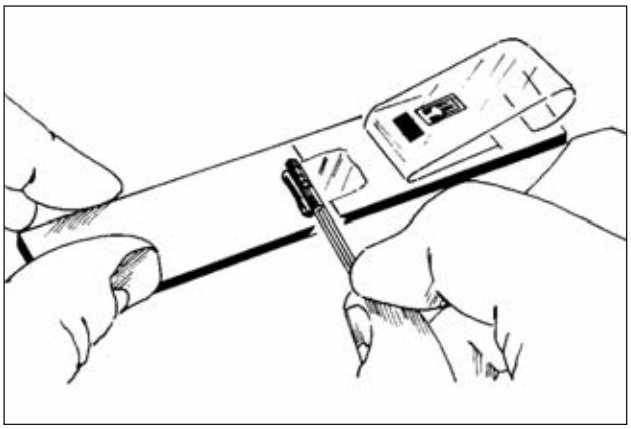
Realign properly and firmly anchor down at least one end of the tape to the specimen. This realignment can be done without fear of contamination by the tape mastic if the recommended gauge installation tape is used. This tape will retain the mastic when removed.

STEP 02



Lift one end of the tape at a shallow angle to surface (about 45 degrees) until gauge and terminal are free of specimen surface. Tuck the loose end of the tape under and press to the surface so the gauge lies flat with the bonding side exposed. In some cases this may be difficult because of space limitations. If this situation occurs, leave enough slack in the tape to allow a finger to be slipped behind the gauge to support it while applying the adhesive.

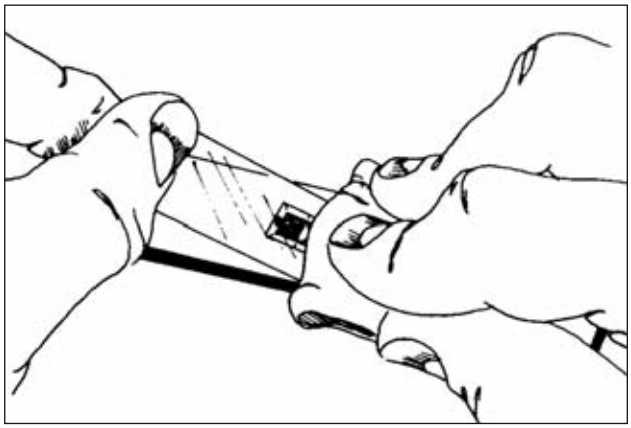
STEP 03



Coat the specimen, back of the gauge, and terminal strip with the prepared adhesive. The mixing rod can be used to apply a thin layer of adhesive over each surface. Be careful not to pick up any unmixed components of the adhesive. To ensure this, it is advisable to wipe the mixing rod clean and then pick up a very small amount of the adhesive from the center area of the adhesive jar.

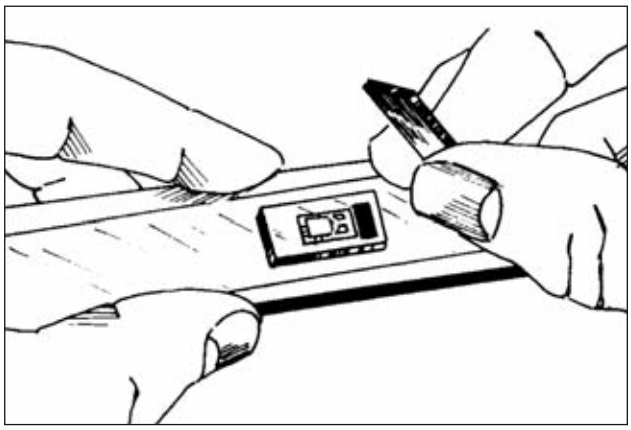
Immediately after coating the gauge and specimen with adhesive, proceed without delay to Step 8. This will limit the absorption of moisture by the uncured adhesive, and the gauge installation tape will serve as a temporary moisture barrier during curing.

STEP 04



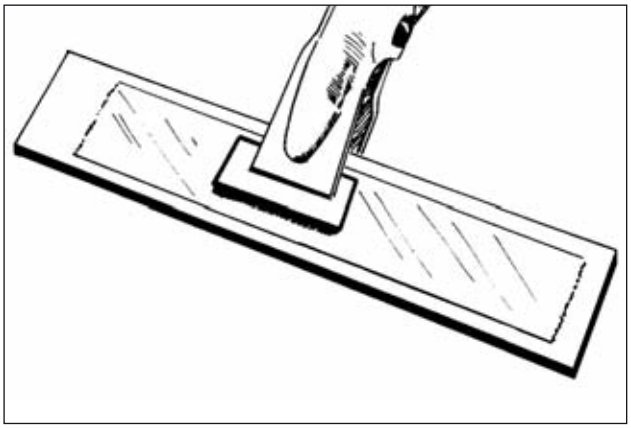
Lift the tucked-over end of tape and bridge it over the adhesive at approximately a 30-degree angle. With a piece of gauze, slowly make a single wiping stroke over the gauge/tape assembly, bringing the gauge back down over the alignment marks on the specimen. Use a firm pressure with your fingers when wiping over the gauge, since the adhesive is quite viscous. A very thin layer of adhesive is desired for optimum bond performance.

STEP 05



Place a silicone gum pad and backup plate (GT-14) over the gauge installation. The silicone gum should be soft (Durometer A40-60) and at least 3/32 in [2.5 mm] thick. This will allow the clamping force to be exerted evenly over the gauge. The area of the silicone gum pad should be used to compute the final clamping pressure.

STEP 06



Apply force by spring clamp or dead weight until a clamping pressure of 5 to 20 psi [35 to 135 kN/m2] is attained. Take special care in making sure the clamping pressure is equal over the entire gauge. Unequal clamping pressure may result in an irregular glueline. Take steps to ensure that the clamps will not slide out of position during cure. A few strips of tape to assist in holding the clamps or backup plate in place during cure may be helpful. Cure the installation in accordance with the recommended cure schedule below.

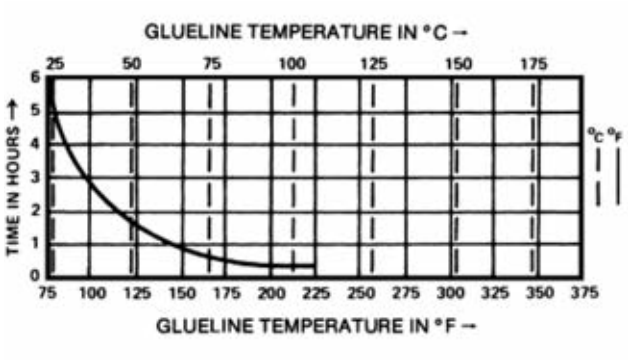
STEP 07

The gauge and terminal strip are now solidly bonded in place. To remove the tape, pull it back directly over itself, peeling it slowly and steadily off the surfaces. This technique will prevent possible lifting of the foil on openfaced gauges or otherwise damaging the installation. It is not necessary to remove this tape immediately after gauge installation. The tape will offer mechanical protection for the grid surface, and may be left in place until it is removed for gauge wiring.

ONCE **PROCEDURE B** IS COMPLETE, PROCEED TO **SECTION 07.2** OF THIS MANUAL TO CONTINUE THE STRAIN GAUGING PROCESS.

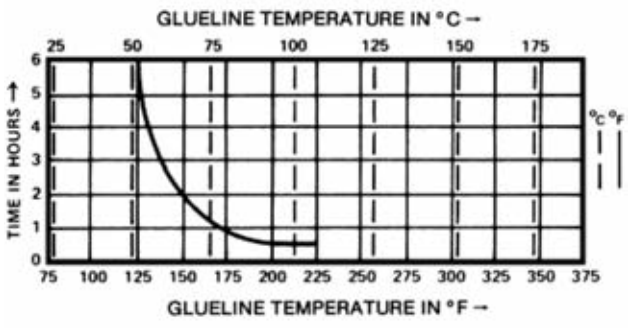
RECOMMENDED CURE SCHEDULES

M-BOND AE-10 AND GA-2



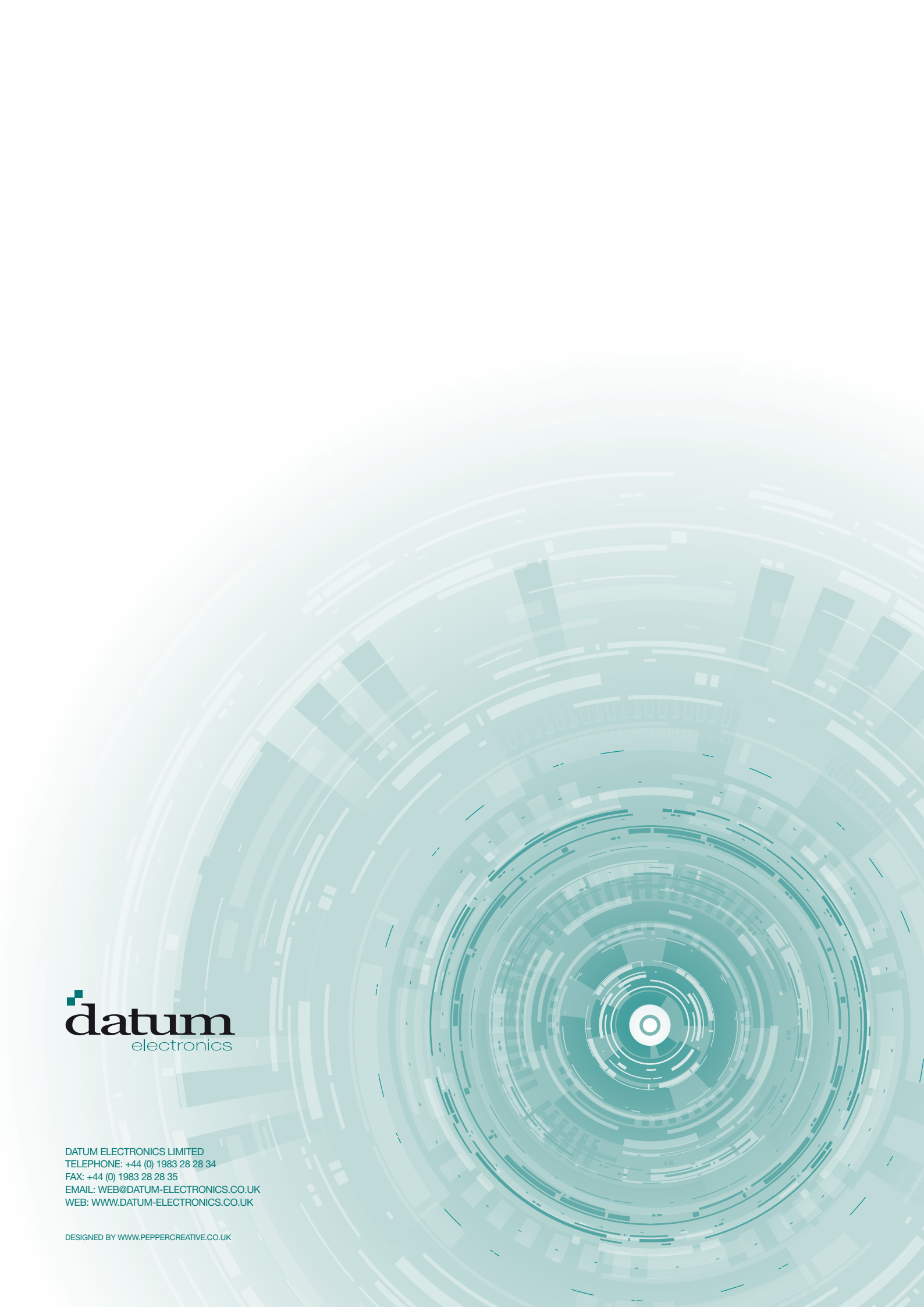
Caution: These systems may not cure properly below +70°F [+20°C]. Postcuring the installation for two hours at least +25°F [+15°C] above the maximum operating temperature with the clamping fixture removed will provide essentially creep-free performance.

M-BOND AE-15



Caution: To ensure proper polymerization, the cure cycle should start within 1.5 hours after mixing.

NOTE: Do not exceed +225°F [+105°C] cure temperature.



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