Automated Bonding Evaluation System (ABES)

Installation and Operating Manual

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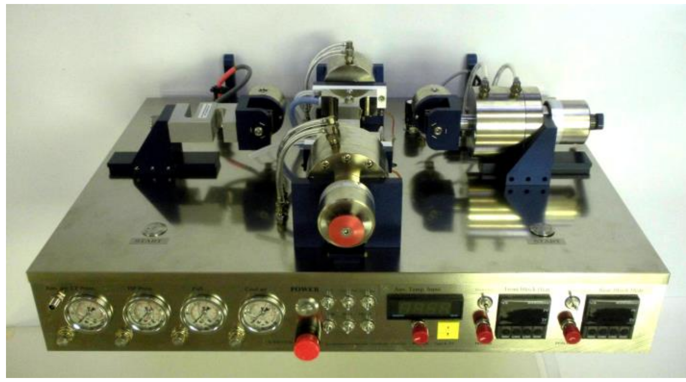
1. INTRODUCTION

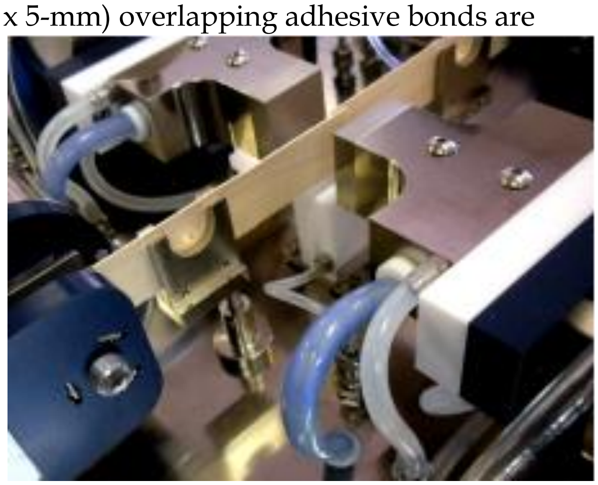
The *Automated Bonding Evaluation System* enables the strength development characteristics of a diversity of combinations of adhesive and substrate to be explored under controlled conditions. A key function is the provision of data on the effect of temperature on the rate of bond strength development for precisely formed miniature test bonds. Such information enables the compatibility of adhesives for product manufacture and assembly processes to be evaluated. In addition to being used to evaluate and compare the bonding characteristics of adhesive formulations, the instrument may be used to explore effects such as compression pressure, spread rate, surface modification, and pre-cure on adhesion for a diversity of adhesive and substrate types. It may also be used as a miniature programmable hot press (without subsequent bond testing), as a programmable tensile testing unit (usually without pressing), or for certain types of "proof' testing. In its high sensitivity configuration, it may be used to explore low-force characteristics such as tack and the strength of very small samples and bonds (in the order of 2mm^2). An overview of the system is shown above.



1.1 The Concept of the Instrument

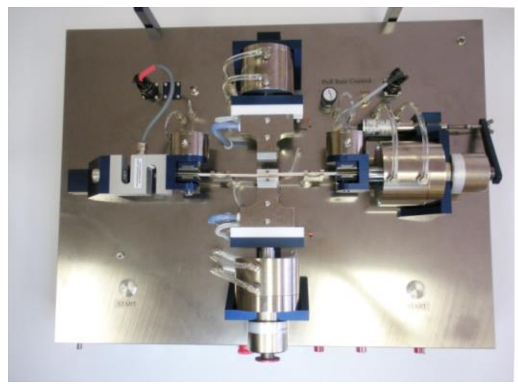
The following emphasizes use of the system for standard bond strength development applications. A wide range of non-standard testing configurations are also possible; some of these are described in appendices (Sections 8-10).

Small (up to 25- x 25 - mm, but typically 20- x 5-mm) overlapping adhesive bonds are formed in the system under controlled conditions of temperature, pressing load, and time. Very rapid heating of bonds to target temperatures is affected by judicious selection of substrate thickness. Bonds may thus pressed for a range of times under near-isothermal conditions. Almost immediately after each bond is formed to the selected level, the force necessary to break the bond is measured



in shear mode. Provision is made for optional rapid cooling of bonds immediately prior to their being tested. Tensile load and gripping head movement are monitored digitally during bond pulling, and shear stress to failure (area-corrected peak load) is extracted in the software. Repetition of the bond forming and testing procedure for a diversity of pressing times, while holding temperature constant, enables isothermal bond strength accumulation with time to be explored. The slope of linearly regressed strength versus forming time data provides a bond strength development rate value. Repeating *this* procedure for a number of different pressing temperatures enables a family of such isothermal bond strength accumulation plots to be constructed. This, in turn, enables the reactivity of bonding systems (effect of temperature on rates of isothermal bond strength development) to be explored. An informative fingerprint of the adhesive-substrate combination's physical reactivity is thus attained. In addition, fully cured bond strengths can be evaluated for a number of pressing conditions.

By using relatively thin (or heat diffusive) substrate samples in bonding studies (typically 0.7 mm for wood and polymers and 0.2- to 3-mm for metals such as aluminum), a broad range of near-isothermal conditions may be achieved very shortly after the beginning of bond forming periods (where the heated pressing heads close on the bond overlap). In this way, near-isothermal bond strength development may be achieved shortly after the beginning of bond forming periods (necessary for the above adhesion reactivity studies). Alternatively, actual industrial bond forming cycles may be mimicked and transient (unsteady-state) temperatures may be achieved for short periods. The latter may include "rapid" systems such as heated roll situations (with overlays and the like).



1.2 How the system works

ABES is pneumatically driven and is controlled digitally with specially developed windows-based object oriented software resident on a PC. Temperatures of the two pressing heads are controlled separately with self-tuning PID controllers. These direct power to cartridge heaters in the pressing heads and also control airflow for cooling through machined ports. Bond pressing force (software selectable between two pre-set values), bond pulling force, substrate gripping, pressing head cooling, and bond cooling pressures are user-selectable with miniature regulators and are sensed digitally with transducers. Collected bond strengths and associated bond forming times used in a given testing sequence are written to user-named files for secondary processing and analysis by the user. Furthermore, load and displacement data for each bond (collected at a user specified kHz frequency during bond pulling) is stored in data files. These may be re-processed to display stress versus strain characteristics of the adhesive-substrate combination or of material samples installed in the instrument.

An auxiliary thermocouple input (Type 'K') is provided. This feature enables miniature thermocouple probes to be positioned in glue bonds in order to monitor temperatures during bond pressing and cooling (if activated). When employed, sensed temperature is displayed on the front panel of the interface module and may also be recorded digitally during bond pressing and, if activated, cooling periods.

A range ***of accessories*** are available, including:

- Pneumatically driven sample-cutting device
- Bond sealing and computer controlled gas (including steam) injection system
- Miniature electronically driven adhesive application system
- Miniature anvils, pneumatic grips, and load transducers for micro-sample pressing and testing.
- Diverse gripping anvils tailored to substrate hardness and special shapes

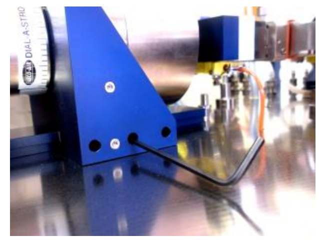
These are described in sections 6 through 8 of the manual.

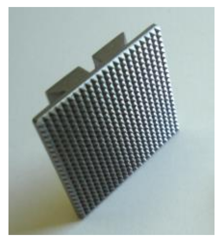
2. QUICK START APPROACH

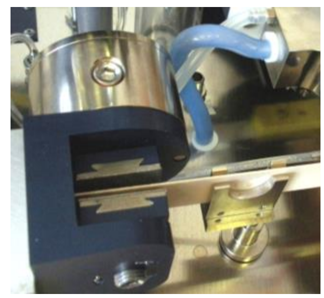
Users are encouraged to read the whole manual (section 3 onwards). The essential aspects of running the system are, however, summarized here for quick reference.

2.1. Set up and Power On

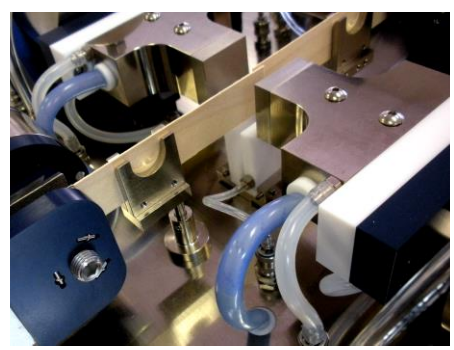
Ensure that the USB cable connection is made between the computer and instrument and then boot up the computer (the USB power is necessary for establishing the correct start condition for the instrument). Do not, however, activate the control program at this stage (see below). Before turning on power to the instrument, BE SURE the instrument is connected to an electricity supply of 115VAC. *An appropriate isolating power transformer MUST be employed if mains electricity is 220/240 VAC*. Turn on the air supply of 0.7MPa and power up the instrument.







Check the physical configuration of the instrument (including press head position, gripping anvil selection, bond overlap and alignment, and air pressure settings). If low-force measurements are to be made, install the appropriate non-standard transducer. Be sure to enter the appropriate sensitivity in the setup screen of the software (described in Tab 6 below). Air pressure settings for bond pressing force, cool gas pressure, maximum pulling force and an auxiliary input may be measured most accurately by employing the digital meters which display settings in scientific units of force and pressure as pertinent (Tab 5 in the software).



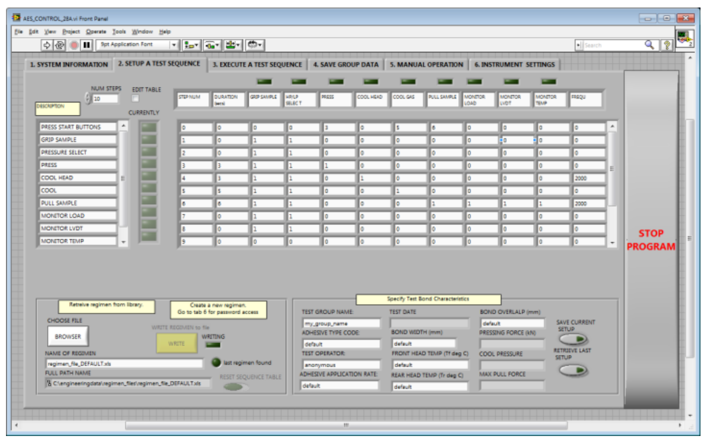
With electrical power and air supply turned on, select the desired pressing temperature on the ABES controllers and allow them to stabilize to within 1^{o}C). Be sure to activate protective barrier cool air if set temperatures exceed 150^{o}C.

Run the Control Program

Click the ***AES Application*** icon on the home screen (the desktop within the Windows 8 platform); the welcome screen (Tab 1, containing a condensed version of information here), will appear. Maximize the screen and, if necessary, move it up so it is fully displayed. Tabs lay along the top of the active window.

Now use Tabs 2, 3 and 4 interactively as follows:

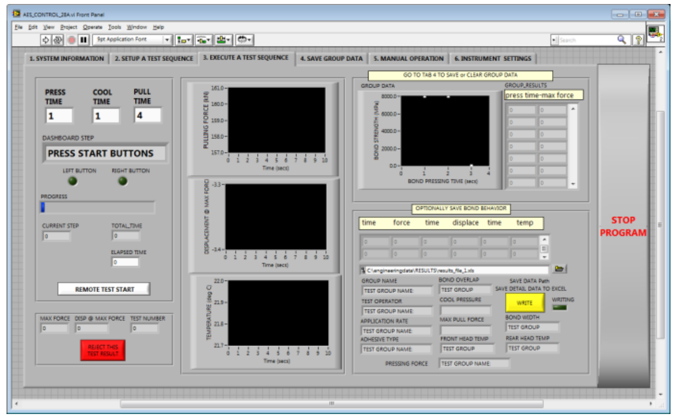
- <u>Tab 2: Set up a test regimen</u>



Use this screen to specify how the instrument is to be run (the type of testing regimen to be used) and to specify test bond characteristics (bond dimension, adhesive and substrate types, head temperatures, operator name etc. Time/date and current pneumatic settings are automatically live-uploaded. Be sure to save entered bond characteristics with a unique specified file name using the save prompt (upper button in lower right zone).

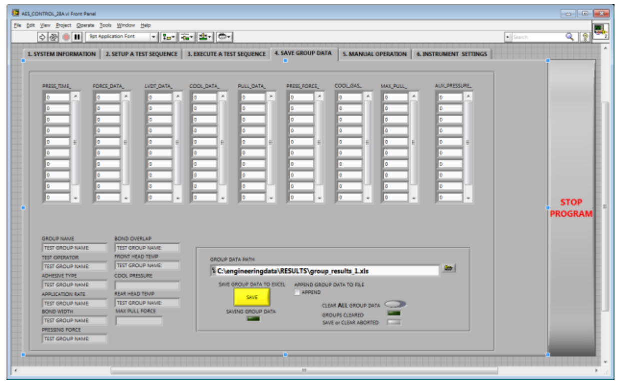
A library of operating regimens (sequences) is provided (such as bond testing either with and without cooling and lateral restraint, duration of load testing, cyclical loading, elasticity and yield strength, and sampling frequencies up to 2 kHz etc.) Advanced users may also use the Tab 2 screen to create and save their own unique regimens. This is a password protected (via Tab 5) activity. Alternatively, users are encouraged to contact the manufacturer who will generate testing regimens to perform special functions. Such regimens are easily emailed and installed by the user. The last-used regimen is automatically resident upon software restart so repeated setup is normally unnecessary.

- Tab 3: Execute a test sequence



Use this screen to run actual tests (having defined a test regimen in Tab 2 or using a pre-installed one (often the case). First specify individual test variables (principally bond pressing and optional cooling times) in Tab 3 and then load a prepared sample pair into the instrument. Be sure to push each sample against the rear stops in the gripping heads so overlap length is attained precisely (typically 5mm) and ensure each sample is resting down on the inner platforms of the sample supports. Activate the test run either by simultaneously pressing and holding down the two illuminated start buttons on the ABES platform or use the on-screen soft-start ("remote test start") button. The sample will be formed and tested according to the resident (Tab 2) sequence (likely involving grip activation, press closure, bond cooling, press opening, and bond pulling) Progress during a test sequence is displayed symbolically and numerically on screen and collected data (load, deformation, temperature with time during bond pulling) displayed graphically upon cycle completion. Detailed behavior of individual tested bonds may *optionally* be saved in Excel format (not normally necessary, but can be used for stiffness calculations etc.) by using the "save data" prompt on TAB 3 (be sure to specify a unique file name within the RESULTS directory. Otherwise complete a set of tests for a range of pressing times. Use the "accumulated bond strength data" scatter plot display as a planning guide for selecting appropriate bond pressing times in order to achieve a satisfactorily clear bond strength development trend. When the set of tests is complete, save the derived data by entering TAB 4 (see below).

- TAB 4: Save test sequence data



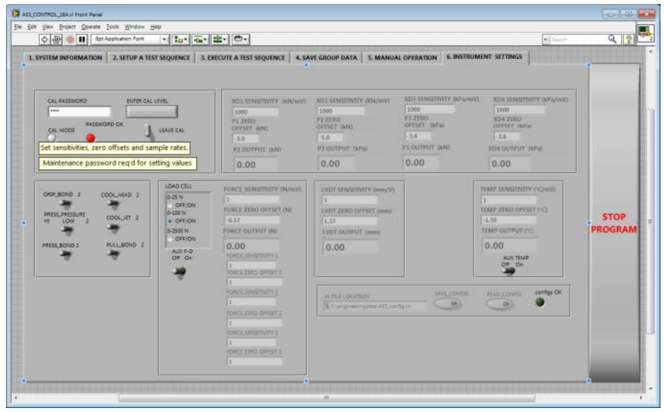
Use this screen to save the accumulated bond strength development data array (typically strength *versus* isothermal pressing time) in Excel format for subsequent analysis. Use the save prompt and be sure to enter a descriptive and logical file name within the REULTS directory.

Derived data are saved in pre-formatted Excel files deposited in a user-named directory. Excel macros are presently being developed for graph generation, regression analysis, report generation, and, where specified, material property such as modulus and yield strength calculations.

- TAB 5: Operate the instrument manually

Use this screen for a diversity of non-standard purposes instead of using automatic uploaded sequences (as above). Soft toggles enable each physical function to be activated independently (including: Pull bond, Cool head, Cool gas, Press bond, HP/LP press select). Load, position and temperature are displayed in real time and also may be logged as needed (for selected duration and sampling frequency). Four pneumatic pressures are also displayed dynamically (pressing force in kN, max. pull force in kN, cool gas pressure in kPa, aux. input in kPa).

TAB 6: Instrument settings and calibration



Use this screen for specifying installed transducers and setting calibration values for the instrument (transducer sensitivities and non-standard devices). Calibration methods are prompted. The screen is password protected. A supplemental screen, TAB 7 (raw data streaming, not shown), is accessed via TAB 6 and is principally for service verification.

Be sure to save collected data and STOP the program before shutting down the computer or disconnecting the USB cable.

Shut down the instrument and turn off the air supply when leaving the instrument over-night.

3. INSTALLATION OF THE INSTRUMENT

3.1 Parts list

The system consists of two main components:

- Bond forming/testing platform (main unit)
- Control software - resident on a provided laptop PC computer.

In addition, the following ancillary components are included:

- Air supply lines (3.1-mm id urethane tubing with fittings)
- Lead for 115 VAC power supply.
- USB-2 Cable (rectangular one end and square on the other)
- Miniature Type-K thermocouple probes for auxiliary temperature sensing
- High sensitivity (125 N range) load transducer
- Spare pneumatic parts kit
- Alan wrench set (Imperial units)
- Manual (electronic and hard copy formats)

3.2 Positioning the instrument

Position the instrument on a laboratory bench equipped with mains electricity and lab air supplies nearby (see below). The bench area should be at least 750 mm deep and approximately 2.5 m wide to provide sufficient working space for the instrument, the computer and sample handling. Head space of not less than approximately 1.6m to full bench depth is necessary for operating the instrument with the cover installed and open. The laptop computer may be positioned to either side of the instrument.

3.3 Electrical and air Services

3.3.1 Electricity supply

The system runs on **110-120 Volts, either 50 or 60 Hz** and nominally consumes 310 Watts (500 Watts when the steam generation accessory is installed). Systems installed in locations where 220/240VAC is standard **MUST** be run off an isolating (not auto) transformer power supply. On NO ACCOUNT should the system be connected directly to electrical supplies exceeding 120VAC. Model Medical-600 from Toroid, Inc. in N America, or Model USA 500 from Torex Ltd. in Australia are suitable power supplies. Such a power supply is normally provided with the instrument. A 4Amp fast blow, 20x5mm fuse is mounted in the power inlet receptacle of ABES (see photo to right).

3.3.2 Air supply

Regulated air of 0.7MPa (95 psi) is necessary. Deviation of up to plus 10% but minus zero is acceptable. Air should be clean and free of suspended water or oil but need not be of medical clarity. Consult the manufacturer if in doubt. The system may also be run from a nitrogen bottle if equipped with appropriate regulator. The 3.1mm id tube with quick connect should be attached to the "Air supply" port on the left side service cluster.

3.3.3 Bond cooling gas

Where the optional bond-cooling accessory is to be used (see section 4.6), special consideration may need to be given to the potential for contamination of sample surfaces if the main air supply line has additives in it (oil, water etc.). Under normal circumstances this is not a significant issue since cool gas acts on the exterior of the sample surfaces. An auxiliary port is, however, provided on the ABES unit for alternative bond cooling gas. This option is provided in case it is desired to separate the demand for cooling gas from the regular system air supply. It is also possible to inject exotic gasses with active cooling characteristics (such as pressurized volatile liquids). Consult the manufacturer for limitations on gas type and associated safety precautions (toxicity, combustibility and environmental acceptability). Connect the auxiliary gas supply to the quick-connect port on the left side input cluster (marked "Aux. cool gas"). This gas pressure may not exceed 0.5MPa. Activation of the cooling function remains under software control when such an auxiliary supply is used. [See section 4.6 for installation and use of the bond cooling function].

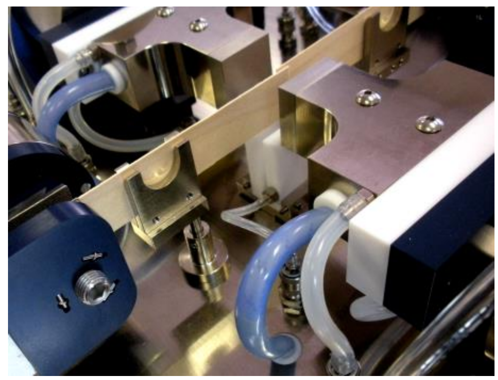
4. PRIMARY INSTRUMENT ADJUSTMENTS

Start-up involves three basic stages:

1. Check the geometric setup of the instrument and adjust as necessary
2. Apply mains power to the system and set temperature controllers
3. Boot up the computer and use the program interactively.
4. Adjust pneumatic regulators

4.1 Temperature Control Settings

Under normal operating conditions, both pressing heads (labeled Front and Rear) should be set to the same temperature. It is, however, possible to select asymmetrical temperatures for special applications (such as directly simulating an industrial process where heat is applied from one side, but where some "cold side" warm-up or heat sinking may occur). The controllers will have been run through their "auto-tune" cycles and derived control constants retained permanently. Set point 1 is used for control (set point 2 is unused).



Use controller buttons as follows:

1) Press MENU button **ONCE** to edit set point 1
2) Use MAX button to select digit location (will flash)
3) USE MIN button to scroll to required value in digit location
4) Repeat stages 2 and 3 as necessary and then Press ENTER button once to store desired value
5) Repeat this procedure (1-4) for the second controller.

The controllers will immediately begin heating.

Refer to the manual for the Omega CN7000 controllers if necessary (Appendix 1).

Alarm 1 is pre-programmed to actuate cooling of the pressing blocks when actual temperatures exceed set point by 1^{o}C or more. Cooling air will automatically come on occasionally under normal operating conditions (to minimize overshoot and maintain set-point). Cooling will automatically come on for prolonged periods when a new set point below the old value is selected. This will hasten cooling to the new value. The pressure of the pressing block cooling function is factory set.

Three-position toggle switches (located under the on/off buttons for each controller) may be used to select block cooling functions. These are used to select one of the following:

- UP: automatic switching by the controller (this is the normal condition)
- CENTRE: off (no cooling)
- DOWN: manual switched for special situations where rapid cooling without PID control is desired.

The cooling air pressure is adjustable with a regulator mounted within the input/control cluster (labeled "block cool") on the left side of the instrument. It is factory set and should not need adjusting under normal circumstances.

To start up the heating system, turn on main power to ABES (but not the computer or air supply) by pressing the on/off button on the front control zone. NOTE: if the start button fails to illuminate then check that the red emergency stop button is set (pushed in) and the on/off rocker switch on the power input cluster is on. Then press the red on/off buttons for each of the controllers. Both temperature controllers will go through a brief (5 second) pre-check and then begin controlling. Be sure to set the desired temperature (set point 1) very shortly thereafter, otherwise unnecessary heating and resultant delays in reaching target temperature may result. **Set temperatures must NOT under ANY circumstances exceed 150°C (or 265°C if the High Temperature (HT) option is installed)**. Allow about 15 minutes for the heads' temperatures to stabilize. Fluctuations of +/- 1.5°C are to be expected under normal use. If greater deviations occur then wait until the system re-stabilizes.

IMPORTANT note for HT operation:

The instrument must be protected from internal damage if temperatures between 150°C and 265°C are selected (for instruments manufactured with the "HT" designation. This is done by manually activating the PROTECTIVE COOLING FUNCTION. An auxiliary input port and regulator is provided in the input cluster (named "Barrier cool"). Activate the function by turning the regulator until a modest air flow is audible. Normally, the air for this function is routed from the main air supply (looped out) when the system is commissioned on site. An alternative auxiliary supply may be employed if main air supply is of limited flow rate or costly to generate (e.g. from a Nitrogen bottle). Barrier cool air can be of low

grade and need only be around 0.3MPa (35psi).

4.2 Pressing Control and Settings

Bond forming pressures (marked PRESS-HP and PRESS-LP on the front control bank) can be selected over a wide range. Pressures are adjusted with knurled regulators situated alongside a marked pressure gauge. Actual values applied to the bond depend upon the target pressure and the bond area. Force settings are displayed in kN onnthe gauges (TAB 6).

4.2.1 Optional Bond Restraint

In order to minimize lap distortion (twisting) during pulling of some types of bond, the pressing pressure may be automatically reduced (in the software) to a second pre-set value momentarily before the bond is pulled (at the end of the bond forming period). Selection of this pressure (PRESS LP on the front panel) is influenced by a number of factors (including bond area, bond overlap, adherend thickness, and the ratio of adhesive to adherend stiffness). Suggested values have been arrived at using available stress analysis theories (FEM) for lap-shear bonds. Clearly, if activated, PRESS-LP should be minimized to avoid frictional drag as the bond fails.

It is advised to use this option **only** when testing non-standard adherends with a thickness exceeding approximately 1.2 mm. The following guideline is provided for such non-standard adherends of 1.2 mm in thickness and 20mm in width:

PRESS LP = 1.2 x L

Where L = bond overlap (mm)

Please consult the manufacturer for further guidance on this matter.

Pressing block cooling pressure:

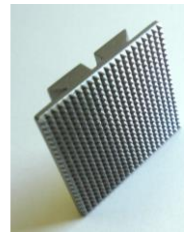
As mentioned above (temperature control settings), this pressure should not need adjustment under normal operation. If needed, the regulator adjustment is to be found on the side of the unit (marked "Block cooling pressure").

Bond cooling pressure (when this optional function is present):

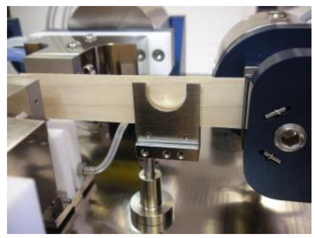
Bond cooling places a significant demand on the air supply to the ABES system. For this reason, careful selection of computer control sequences (see Tab 2 Regimens) are required if other pneumatic functions (particularly gripping and bond pulling) are not to be impaired. Still, quite effective, but not maximum, cooling may be achieved by using internally regulated air. Consult the manufacturer for more guidelines on this, together with calibration data for bond temperature versus cooling pressure, cooling time and bond starting temperature.

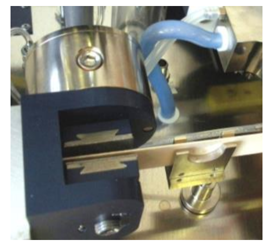
4.3 Gripping Adjustments

Grips with precision machined interchangeable rhomboidal inserts are used to grab the free ends of the samples prior to bond pulling. Standard gripping inserts are stainless steel with a precision-machined rhomboidal pattern (diamond impregnated and red anodized alloy inserts are available on request). For normal operation (when testing all materials except very soft or brittle ones, such as rubber or honeycomb), gripping pressure should be set to maximum (to maximize tensile load

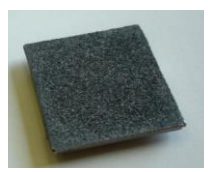


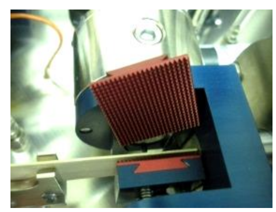
that may be transferred to bonds or material samples). The adjusting regulator is located in the input cluster and is marked "Gripping force".





The standard stainless steel inserts reliably enable wood samples of 20mm width to be gripped well in excess of the full pulling capacity of the instrument. This is in excess of 1200N when air pressure of 0.7Mpa (100psi) is applied to the pulling cylinder, and corresponds to a shear-strength of 12MPa on a 20 x 5mm bond. Diamond impregnated inserts are appropriate for gripping very hard materials such as ferrous and non-ferrous metals, glasses and hard polymers. Diverse profiles may be machined into blank (smooth) stainless steel inserts for special applications such as gripping MEMS and biomedical samples.





Adherent samples with thicknesses up to 8mm may be centered within the loading train by adjustment of the central ball-end thrust screw on each gripping head. This adjustment should be affected in concert with positioning of the front press head's stopping position (see section 4.4.3 below).

7. ACCESSORIES

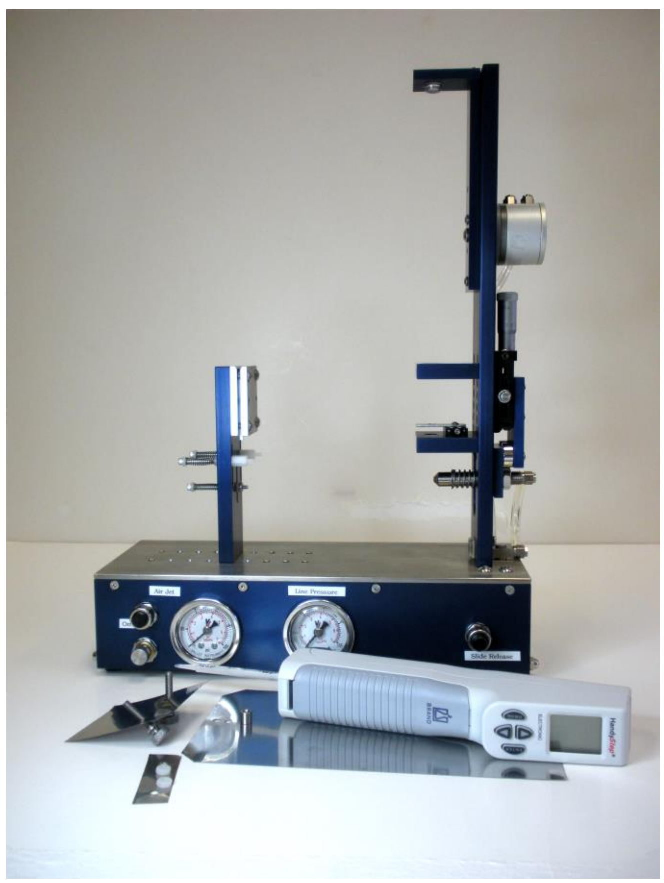
Miniature precision adhesive application accessories:- A miniature and highly controllable ***liquid application system*** has been developed specially for ABES. This enables adhesives and other liquid chemicals to be accurately and quickly metered onto small bonding surfaces. It can affect spread rates from as low as 2 grams/m^2 and up to full saturation with some provision for droplet size control. Adhesive is held airtight immediately prior to application. Sprayed quantities are minute, however a ***vented enclosure*** is available to contain toxic reactants if necessary, as well as a miniature sonic device to meter ***powdered adhesives*** onto adherend surfaces is also available upon consultation with the manufacturer. Standardized samples for use on ABES III and the application accessories are prepared on the **precision pneumatic sample cutting accessory**. Details on these two accessories to follow.

A **hinged cover** protects the instrument and enables toxic reactants to be contained during use. It includes a fan-assisted extraction port (internally powered) to maintain a small negative internal pressure (linking to an umbilical), along with sliding access door for sample insertion and removal.

7.1 SPRAYING DEVICE.

7.1.1 Introduction

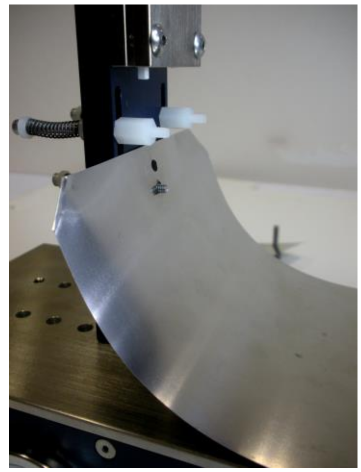
An electronic pipette dosing device (Handystep® made by Brand GmBh) is used to meter liquid adhesive into a regulated air path. Tri-axial (x-y-z) control of the adhesive supply tip's position relative to the air jet is affected with two precision micrometer screw slides and an adjusting nut. Once charged with adhesive, the Handystep® is mounted and held in position with a pneumatically locked sliding clamp. The adherend sample insertion and shielding aspects of the instrument are affected with adjustable spring loaded stops and stainless steel shields (for durability and cleaning).



7.1.2 Assembly Instructions

1. Install the three stainless steel shields:

One set of shields are shipped in the Brand Handystep® box. Some spare nuts and aligning pins are also provided. Do each of the following in order:



- *Main base shield (210mm x 102mm, vertically aligned holes)*
  Remove the nylon hex stand-off nut from the central stopping stud on the sample support column (leaving the small steel retaining nut in place). Then slide the shield into place by passing the inner hole over the steel stud. Gently push the free end of the shield down onto the base plate and flex it under the clear plastic stop mounted near the base of the vertical spraying column. Replace the hex stand-off nut and finger tighten *very* lightly. Try to retain the spring loaded stud position, though its location is marked with a small stamped dot on the column. Slide the stud up or down to position it if necessary.

- *Adhesive shield (21mm x 45mm, horizontally aligned holes)* Remove the two tiny nylon nuts from the nylon threaded studs and slide the shield onto the studs; replace the nuts and finger tighten them very lightly. Try to retain stud positions, though locations are marked on the vertical blue column with small stamped dots (there are spare nuts in the plastic box too – because they are easily lost).
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- *Top plate shield (64mm x 51mm, horizontally aligned holes)* Remove the two nylon knurled screws from the nickel sample guide plate, position the shield and gently replace the screws (no need to tighten them down).

Check the setup by inserting a standard wood sample into the instrument and check alignment of the second shield. Adjust it if necessary so that an appropriate amount of the sample is exposed **(about 7mm for a preferred bond pressing overlap of 5mm).**

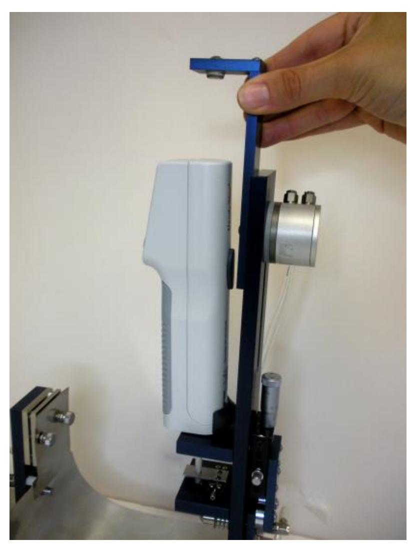
7.1.3 Using the Handystep® pipette

Read the manual for the BRAND HandyStep® Electronic and understand its operation (the manual is rather confusingly laid out!). The micro-sprayer is designed to be used with the **0.5 ml** tip and ten of these are included, along with samples of larger ones in the Handystep® box (not used). Tip re-order information is provided in the box (ref. no. 702370). Mount the battery in the unit and ensure it is fully charged (it may be ready to use because it was charged before shipping, but is should be checked). Carefully install a 0.5ml tip in the device (be very careful to slide it in laterally and close (slide down) the grey locking piece firmly according to the manual. If the Handystep® fails to move (error message 003), then **fully re-charge the battery** for 3hrs or till the green light flashes on the base unit (the whole instrument should be mounted into the charging base for this). Keep the unit fully charged at all times. It may be worth buying a second battery if prolonged use is anticipated (Brandtec.com).

Experiment with the Handystep® device and its menu using water before mounting it in the micro-spray unit. Initially it is suggested to set the instrument for the smallest step dosing amount (ten steps) using the menu. Also set the movement rate to the lowest value (of three).

7.1.4 Operation of the micro-sprayer

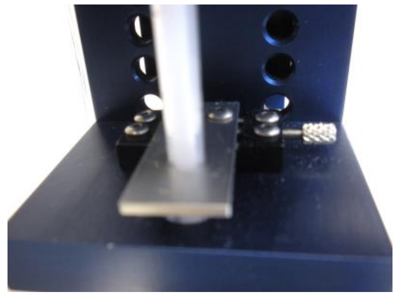
- Connect the air supply to the unit (85-100 psi, as for ABES-II) using a quick connect provided and turn on the air (rear toggle switch).



- Fully raise the sliding clamping arm (on main column) while pressing the release button on right of front panel.
- Load the Brand Handystep® unit with water and gently mount it in the micro-sprayer by inserting the tip-end through the large hole in the upper blue table piece and then through the small guide-hole in the small nickel guide plate below. Lower the unit so it rests vertically on the upper blue supporting platform. Install it with the LCD display facing forward. Let go of the unit so it rests level on the platform and then lower the clamping arm (while holding down the release button) so the rubber foot presses firmly on top of Brand Unit. While pressing

down, release button. The Handystep® should now be in place with its tip intersecting the air nozzle hole. **Now refer to Appendix 1 below** for checking and, if necessary, adjusting the relative position of air jet and adhesive nozzle.

- Air pressure setting:
  An air pressure of 20psi (pre-set) should be used for most liquid adhesives (adjust the regulator next to the marked gauge if necessary). Pressure for the air jet will need to be increased when spraying high viscosity adhesives (above about 800cp). Very high viscosity adhesives may not be sprayed.
- Practice spraying with water before using adhesive. With the air supply turned on and Handystep® loaded with water and mounted, insert a wood sample into the support frame (touching the nylon stop). With the air jet button (left panel-button) pressed to activate air jet flow, gently (with clean hands!) press the rear activation button on the Handystep® a few times. The plunger should move down and water should be sprayed each time. Immediately release the air button. Repeat spray action and verify water deposition on the sample.

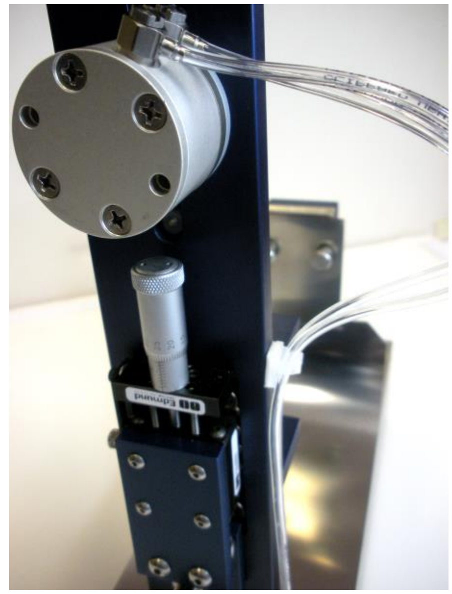


- Adjust the shoot direction of the air head so that the spray cone (area sprayed) is centered on the sample – particularly in the horizontal plane. In other words, look at the sprayed sample and see if there seems to be asymmetry in fluid deposition. If necessary, adjust the three centering hex screws on the vertical traverse slide mounting block with a hex wrench provided (see photo). The single (front) adjuster should best be used.

- When spraying adhesive, **be sure** to wipe any adhesive from the sides of the plastic nozzle (where dipped into the bottle) before inserting it into the sprayer (otherwise adhesive will contaminate the mechanism and air jet).
- If desired for specific studies where specific target spread rates are required, calibrate sample mass gain due to given pipette movement by using a micro-balance (weigh initially and after a substantial deposition of adhesive). In this way, derive a *"mass gain per unit of plunger movement"* value. Once calibrated, set the Handystep® injection volume per dose to achieve the desired target spread rate.
- Be sure to avoid adhesive contamination of the micrometer slides and the Handystep®. The whole unit should be sprayed with a FTFE release compound to facilitate cleaning. It is suggested that cleaning is conducted regularly and frequently and that the release compound is re-applied sparingly but regularly on all surfaces, including the air nozzle and micrometer slides (Use P.T.F.E dry film mold release – no. S00311 made by "Sprayon Products group" or similar.

Appendix: Adjusting the adhesive dispensing nozzle position.

A miniature slide is used to centre the plastic adhesive tip over the end of the air jet in the horizontal plane – by moving the small stainless steel guiding plate. Carefully centre the plastic pipette over the air jet hole by eye by turning the tiny adjusting screw back and forth. (use a 5/64"allen hex-wrench which fits into the end of adjusting screw if it helps to turn the adjuster).



The air jet adjusting nut is pre-set for a 0.7mm clearance between the air jet and adhesive injector (the side of the adhesive injector just touches the end of the air jet). Turn the nut clockwise to achieve greater injector-jet clearance (not recommended, however).

The larger micrometer slide on the rear of the blue vertical column enables the vertical offset of the plastic adhesive tip relative to the air jet to be adjusted. This may either be set by eye or, for high precision a small steel pin may be inserted into the air jet. For this purpose, hold the blued end of the pin and insert the other end into the air-jet hole. Slide the pin in till it tips slightly upward (somewhat beyond its mid-point). Then adjust the micrometer so that the adhesive tip just touches the pin. Carefully rotate the micrometer thimble further so as to adjust the position so that the pin is ***approximately horizontal*** (the pin will be very lightly pushed up and down by the adhesive nozzle). Then carefully remove and store the pin. The vertical position of the adhesive jet relative to the air jet is now precisely set. This adjustment should be checked periodically, but should be stable for repeated use of any one pipette.

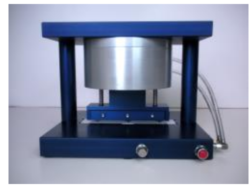
The system should now be ready to use. Be sure to re-charge the battery whenever possible.

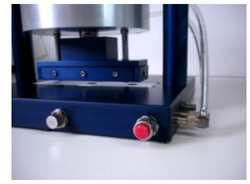
Contact Philip Humphrey (tel. +541 760 9347; email: humphrep@gmail.com) with any concerns.

7.2 SAMPLE CUTTER.

This pneumatically-driven device allows for precise, uniform sample sizes. Blades are interchangeable.

7.2.1 How to make samples.





1. Hook up air supply and adjust pressure.

2. Place material under stamping block.

3. Press the red button, holding long enough for material to be stamped through. Adjust pressure if necessary. It is advisable to use precisely the necessary pressure in order to preserve the life of blades and Teflon receiving pad.

4. Remove material by carefully pressing down on either end of stamping block. Refrain from placing fingers underneath.

7.2.2 How to replace razor blades.

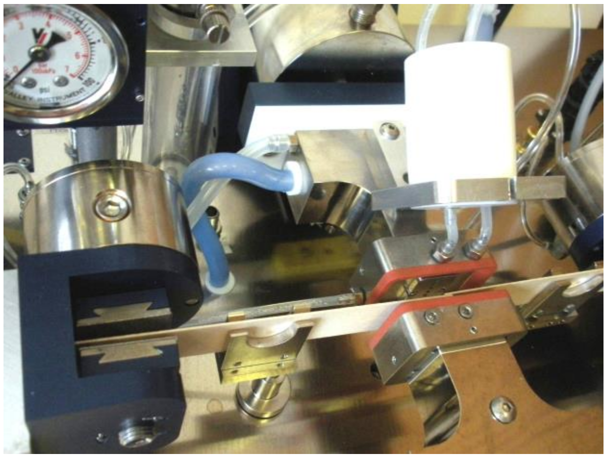
1. Remove base.

2. Remove holding plates.

3. Replace blades and reassemble, aligning blades as precisely as possible on the long sides before tightening the ends.

7.3 FLUID INJECTION SYSTEM.

7.3.1 Principle of operation



Steam is generated within a miniature electrically heated unit which is mounted directly onto one of the two sealing heads which is, in turn, mounted onto the rear pressing head of the ABES-II instrument. A second sealing head is mounted on the front ABES pressing head. When closed onto a sample pair mounted into the system, peripheral sealing is affected with flexible high temperature silicone rubber annuli embedded in the surface of each sealing head. The edges of the sample pair are feathered in order to achieve the necessary seal. Water vapor pressure within the temporarily sealed treatment chamber is dynamically controlled using a closed loop approach to steam injection based on electronically sensed vapor pressure around the sample.

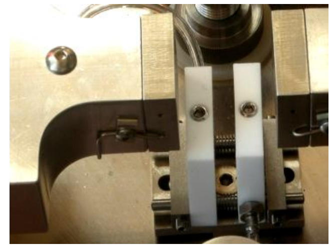
For this purpose, water is dynamically metered into the steam generator from a control unit which sits on the base platform of the ABES instrument. A PID process controller, electronic proportional valve and pressure transducer combination is employed to dynamically regulate air pressure which acts on a rechargeable water reservoir. Water enters the generator via a very fine (typically 0.008” dia.) orifice. The control unit also provides PID temperature control of the steam generator.

Overviews of the main components before and after installation. *Steam micro- jet.*

7.3.2 Installation on the ABES-III platform

With ABES-III mains power and air supply OFF, do the following:

1. If installed, ***remove the cooling head*** from ABES-II as follows.

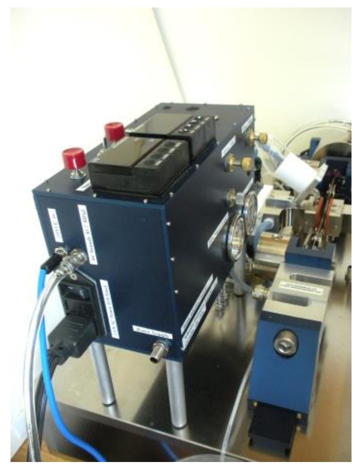


   a. Unscrew the removable screw fittings which connect the two air supply tubes to the base unit.

   b. Insert a 1/8″ hex wrench down between the white PTFE blocks and into the flat head cap screw below. Undo the screw while letting the head rise (the screw is trapped in the head).

      a. Ease the head out from between the pressing heads. BE SURE to save the small stainless steel collar (retain it on the screw with a 10-32 nylon nut, supplied).

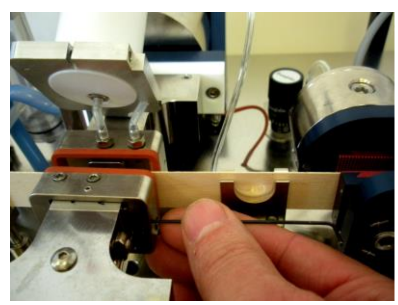
2. Mount the blue control unit and steam generation/injection assembly on ABES-II base:



   Position the control unit (blue module) on the left/rear quadrant space directly behind the left gripping head, with pressure gauges facing forward.

3. Mount the sealing heads on the ABES press heads:

      a. Carefully maneuver the generator-rear head unit combination (pre-assembled) into place on the rear ABES pressing head. Be very careful not to stress the connections.



      b. Place the sealing heads over the ABES pressing heads, ensuring full contact. Gently tighten the screws on the right hand side (pictured) as well as the top (not pictured). Do this for the front and rear heads.

4. Connect steam generation/sealing head assembly wires and tubes to the control unit:

      - <u>Heater plug</u>: carefully align the indent, push on and tighten locking collar

- Water delivery tube: Select tube that enters steam generator and connect (firmly screw in) to lower port (marked "water delivery")

- Transducer supply tube: Select tube that comes from sealing head body and tracks along the outside of the steam chamber, and connect to upper port (marked "Pressure Transducer In"). (Not to be confused with the vent tube coming from the lower side of the sealing head, which culminates in a needle valve.)

- Connect thermocouple plug (note that blade pins are polarised).

5. Connect electrical power (110VAC and 24VDC) and air line to left end of control unit:

   a. Attach an air line (same spec. as that for ABES and its other accessories) to the air supply port on the control unit.

   b. Connect supplied cord to 24VDC socket on ABES base and other end to Control unit.

   c. Connect mains power to unit (but be sure integral rocker switch is OFF).

7.3.3 Trial activation of selected features

1. Check generator heating

   - Turn on power to unit (rocker switch on power inlet/fuse module)

   - **Immediately turn OFF either controller** if it comes on (red buttons may have been depressed during shipping).

   - Turn on temperature controller (right controller; red button) and check that ambient temperature and set temperature are displayed. Heating will initiate quickly. BE SURE set temperature is NOT ABOVE 220^{o}C (it was set at 190^{o}C when shipped – which is fine). Allow the unit to stabilize at set temperature (should take around two minutes) – **paying close attention. TURN OFF and make an inquiry if anthing seems wrong**.

- Explore how to re-set temperature using SP1 adjustment on controller menu. Do not re-set tuning constants! The system will normally be run at between 180 and 220°C. The default should be as shipped. (note: the controller operates in the same way as those for the ABES head controllers). Ask if not sure. A manual is included.

- Switch OFF the temperature controller (red button).

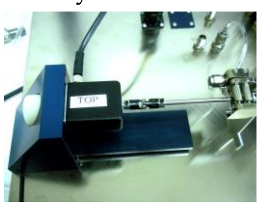
2. Check press closure

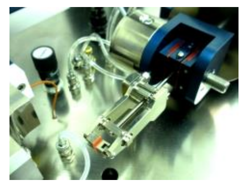
7.4 MicrOgrips and Micropressing heads

7.4.1. Micro-grips and press heads

The pneumatic grips provide minute flexibility in securing samples.

1. Remove transducer assembly from ABES: unplug, and remove with hex wrench.

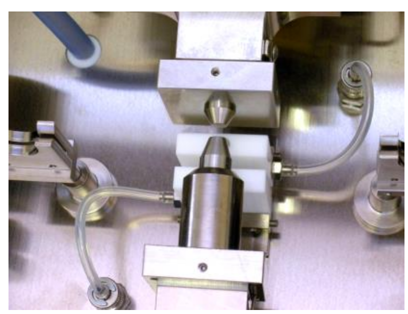


2. Install micro-transducer with nylon bolt, orienting so that the word "TOP" is visible, and so that the pneumatic microgrip stands on its foot facing towards the testing area. Take great care not to apply any torque to the transducer's connections as it is very sensitive.

3. Connect Amphenol plug to port on ABES.

4. Place the other pneumatic microgrip block-end in to the gripping mechanism and attach tubes.

Physical setup data for ABES

Left slide dot distance (from far end of Tee slide)		30.3 mm from double dot
Right slide dot distance	"	56.7 mm from double dot
Front press head dot	"	32.5 mm from dot

ABES Load Calibration procedure

Summary of the procedure

The load transducer and left grip assembly will be removed and then hung over the edge of the bench on a bar which will protrude from under the front/left of the ABES (the ABES will be used as a restraining cantilever weight). The electronic signal connection will be maintained with the aid of an extension cable provided. The gripping head will be used to hold a tab and hook onto which will be hung a light bag. The ABES software (Tab 6, "Instrument settings") will be used while adding known (balance-weighed) weights to the bag in order to explore the relationship between applied load (converted to Newtons) and displayed values. The sensitivity will be adjusted as necessary and then saved.

Parts and tools:

- Transducer support bar (largest piece of blue aluminium, nominally 400 mm long); Part A
- Weight tab (small blue tab with hole in one end and padding on other); Part B
- "S" hook-connector; Part C
- Extension cable (with Amphenol plug and socket on ends); Part D
- Fabric bag, with suspending handles; Part E
- Large (1/2") Allen Hex wrench (in ABES accessories set); Part G

With **computer, electrical power and air supply to ABES turned off**, do the following:

1. Gently slide the large bar (Part A) under the left side of ABES so it lies largely under the left side plate (rather than the plastic area of the underside cover, which otherwise could be damaged). Do this so that about 50-75 mm of the bar protrudes beyond the front and overhangs the bench. The end with the 12.5 mm hole in should be exposed (the large radius cutout on the side of the bar can

locate against the front/left foot of ABES, and the end-slot over one of the base-retaining screws).

Note: if your bench has an elevated lip at the front, then you must improvise clamping of the bar to the bench ***next to ABES****; alongside its left side. The bar* ***MUST be horizontal****.*

2. Disconnect the load cell's electrical connector (black plug) from the base unit, lying to the rear of the transducer assembly. (Note: turn the serrated thimble of Amphenol plug anti-clockwise until it is free to be unplugged; it is initially quite stiff to turn).
3. Unscrew the two serrated air-line connectors that supply air to the left grip head. Please take note of which tube connects to which base fitting. Again, these can be stiff to turn initially).
4. Locate the large hex wrench (Part F) and use it to loosen the large stainless steel hex cap screw that holds the Omega load transducer to the blue rear-angled supporting block. Unscrew the large screw while carefully supporting the gripping head/transducer assembly with your right hand, so that it does not fall. Lift away the head. Retain the screw and also the red fiber washer behind it.
5. Mount the transducer/gripping assembly under the supporting bar (Part A) by passing the large screw through the hole in the bar (from above) and screwing it into the transducer a little way. **There is NO NEED to tighten the screw.** The assembly should hang free and not touch the side of the bench.
6. Use the extension cable (Part D) to establish a link between the transducer plug and the connection port on the base of ABES. Be sure to use the correct gender for each end, and carefully rotate the plug/socket until they engage easily, then turn the serrated thimble on each until they click closed (quite stiff).
7. With the appropriate hex wrench, carefully unscrew (but do NOT remove) the adjusting set screw in the front of the grips so that the space between the anvils is sufficient to allow the padded end of the blue loading tab (Part C) to pass between the grips. Orient the tab so the end with the hole lies vertically below. Then gently tighten the thrust screw so the tab is gripped mechanically. DO NOT tighten it very hard.
8. Pass the metal hook (Part C) through the hole in the gripped loading tab (Part B) and then hang the calibration weight carrying bag (Part E) from the hook.
9. Start the computer, switch on power to ABES and run the ABES program. Select Tab 6 (Instrument settings) and enter the password ("abes") protected status. Be sure that Transducer 3 (the highest load range of the three) is selected (selection circle). Pull down a little on the gripping head and check that, while doing so, the displayed live feed of load on the screen varies a little. If it does not, then check that the sampling toggle is in the ON position.
10. Set the appropriate zero offset value as follows:
    - Set the zero offset to zero (0) for that transducer

- Now set the zero offset to a value equal to the new live feed load value, but of **opposite sign** (+/-).
- The live feed load value should now be at or near to zero.

11. Find three compact objects (probably metal or stone) that each weigh *very roughly* 1kg, and use an electronic laboratory balance to ascertain their weights within about +/- 5 grams (alternatively, if available, use standardized known weights.)

12. Carefully and gently place one of the weights in the bag and then record the live stream load value displayed along with the weight applied. Repeat this procedure twice more, adding one more weight each time (three readings in all, the last one resulting with a cumulative weight of about 3kg; but it could be as much as about 6kg.)

13. Convert the three cumulative weight values to Newtons (by multiplying weights in kg by 9.81) and linearly regress them against displayed live feed load (with applied load on the x-axis). If the derived slope value deviates from unity by +/- 0.05 (i.e. 0.95 to 1.05), then modification of the current sensitivity is necessary. To do this, divide the current load sensitivity value (on the screen) by the regressed slope and insert this modified value in the "load sensitivity" box. Repeat the above loading procedure (steps 14 and 15) to check the accuracy of the new value. If satisfactory, **BE SURE to SAVE** the new setup before exiting password protected status. It is advisable to write down the value, also.

14. Remove the weights and bag and release the tab by loosening the thrust screw as necessary. Now **STOP the program, and TURN OFF the electrical power to ABES**.

15. Remove the load cell/gripping assembly from the bar, re-mount the assembly on ABES (with the large screw, with red fiber washer, and tighten with the hex wrench while holding the transducer horizontal (re-adjust if necessary and re-tighten). Then remove the extension cable and re-connect the plug and tubes as before (with the correct air-line combination).

16. Now turn on power, re-start the ABES software, enter Tab 6, enter password protected mode and re-set the zero offset so as to affect near-zero live load feed, as above, (step 12). This is necessary because of the weight of the assembly when hanging during calibration. Again, **be sure to save the new settings** before leaving password protection.

<u>The system should now be fully functional.</u>

Please note: ***IF*** *the sensitivity value had to be changed as a result of the calibration process, then bond strength data collected earlier with the old sensitivity value in effect may be corrected. This may easily be done by linear correlation based on the ratio of old-to-new load sensitivity values.*

END