SYN·E·O

precision tooling & technology solutions

A Winning Formula for Press-Fit Technology:

Introduction of Servo Electric Presses for High-Speed Data Press-Fit Connectors

Dan Woodward
February 2016

SYN·E·O

SYNEO
precision tooling & technology solutions

History

On April 19, 1991 Dan Woodward and Aaron Arnold formed a company they named Automation Services Group which became known as ASG. Press-fit connectors were becoming popular at that time and they designed an automated connector press with PC control, servo XY stages, and a hydraulic press head. Although the press used sophisticated PC controls and servo motors to position the pressing head and PCB, they discovered the hydraulic system had severe drawbacks. Not only was it impossible to precisely control the pressing speed and force, but stored energy in the hydraulic system would slam the connector to the PCB surface once required force dropped when the pins entered the holes. The presence of hydraulic oil near electronic circuit assemblies also posed a huge quality liability. From this realization a servo electric pressing head and sophisticated press force monitor software was developed specifically for precision pressing connectors. The first automatic all electric servo press for press-fit connectors was delivered in 1995. The first fully automated press for large backplanes with top and bottom tool changers was delivered in early 1997. The name given this press was the AEP-12T, which was derived from Automatic Electric Press with 12 Tons of pressing force. ASG subsequently developed a line of servo electric presses with manual PCB positioning and tool placement that ranged from 3 tons to 12 tons of pressing force. They were known as BMEP (Benchtop Manual Electric Press) and MEP (Manual Electric Press). The entire servo press family quickly became a de facto standard for precision connector pressing throughout the world.

Press-fit today

Much has changed in electronics since the first electric servo press was introduced, but press-fit connectors are more important than ever to today's high-bandwidth electronic circuit boards. Not only are press-fit connectors important, their highly controlled electrical characteristics are critical to providing high integrity electrical signal paths into the gigahertz range. The latest connectors are designed with very small pins and dense spacing. The application of these fragile & expensive connectors on expensive high layer count PCBs requires more control of the press-fit application process than ever before. In fact, the first pass yield on a complex PCB with hundreds of connectors and tens of thousands of pins can be unacceptably low due to human induced variability and handling damage.


Enter Syneo

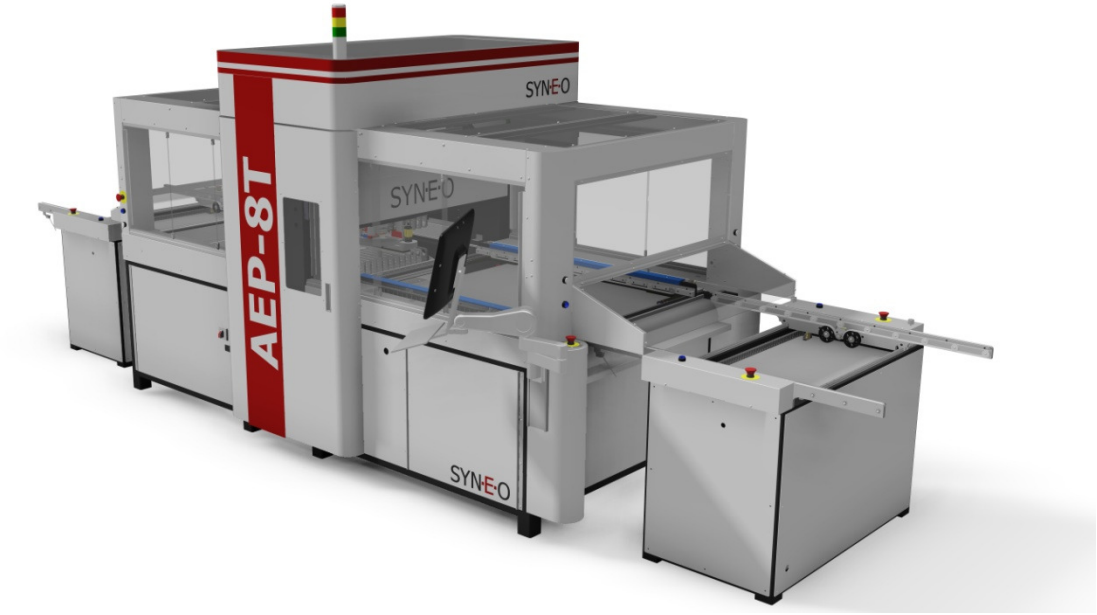
After nearly 20 years on the sidelines, the original team that developed the ASG presses is once again working together. With a clean sheet and a fresh outlook the team has embarked on a path to reinvent the press-fit connector assembly process. The venerable AEP-12T has been reinvented from top to bottom to take advantage of advancements in machine control but also to add features to address the more difficult and fragile connectors. A new line of presses with manual PCB positioning and tool placement has also been completely redesigned to offer more accuracy, sensitivity, and control than previously possible. But all of the presses that are currently operating around the world have not been left behind. Syneo has a complete multi-level offering of retrofit and upgrade packages that can bring any of the old presses to a performance level that exceeds their capability when new. Not only have the hardware and electronics been upgraded to today's state of the art, but the software has been rewritten from a blank screen. It utilizes the latest PC, Windows, touch screen LCD monitors, and Ethernet communications within the machines. All new editors and databases that operate in a familiar way but offer new features and conveniences are provided. Legacy database can be imported into the new presses to simplify migration.

An all new Pick and Place system with vision inspection of the connector and vision driven placement is already in the planning stages. The new and upgraded AEP presses have been designed to accommodate a unique process sequence which overcomes that challenge presented by high density connectors that have very little retention in the PCB before pressing. More detailed information on Syneo's Pick and place companion to the AEP presses will be provide by mid 2016.

AEP-8T

The new Syneo AEP-8T is the re-imagined version of the AEP-12T. The maximum force has been reduced from 12 tons to 8 because we have found there is no need for such a high force in today's applications and this reduction improves the force monitor resolution. The PCB size is the same as previously (36"X48") and all of the configurations from the prior machine are still available including:

- manual or automatic loading of the PCB
- support fixture or bottom tool support
- automatic tool changing



The AEP-8T is available as a new machine or an upgrade from an existing AEP-12T. In the case of the upgrade only the frame, structure, and some of the sheet metal is reused. All electronics, wiring, bearings, and ball screws are replaced with new. In fact, the new AEP-8T now has 7 separate servo axes! The sheet metal skin is either new or old paint is removed and powder coated. The appearance and performance of a refurbished machine is identical to a new machine. In all cases the software is completely new.

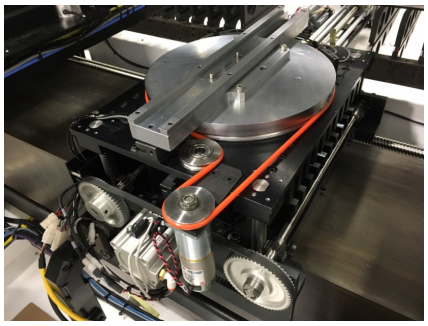
AEP upgrades

All upgraded and new AEP-8T presses share the following improvements.

➢ **Address loose connectors** - One of the challenges of the latest connectors is they have little retention in the PCB before they are pressed. Any vibration or bump during handling can cause one or more connectors to become dislodged and thus cannot be pressed without additional human intervention. Syneo has taken several steps to address this problem.

1. Input conveyors – The buffer conveyors and autoload table have been upgraded from DC motor (on/off) to smooth servo control. When a PCB I loaded into the AEP by conveyor the start and stop are ramp controlled and the speed can be tailored to the application. The belts and drive have been upgraded to accommodate a 100 pound board rather than the previous 50 pounds.
2. Autoload table motion – The autoload table previously loaded the PCB in a raised position and then lowered to the pressing position. Once pressed is raised to unload the PCB. This up/down motion of the autoload table was eliminated because connectors could become dislodged prior to pressing.

3. Bottom tool – The bottom automatically tool rises to support the PCB just before pressing and lowers once the cycle is complete. This was previously a pneumatic actuation with hard stops at the ends of stroke. The tool would rise quickly and sometimes bump the bottom of the PCB causing connectors to become dislodged. The bottom tool assembly is now servo actuated so the speed and height can be precisely controlled. The rise is profiled to be fast but then slow on approach to the bottom of the PCB. In addition to this, the bottom tool no longer needs to be lowered all the way if there are no obstructions on the bottom of the PCB.

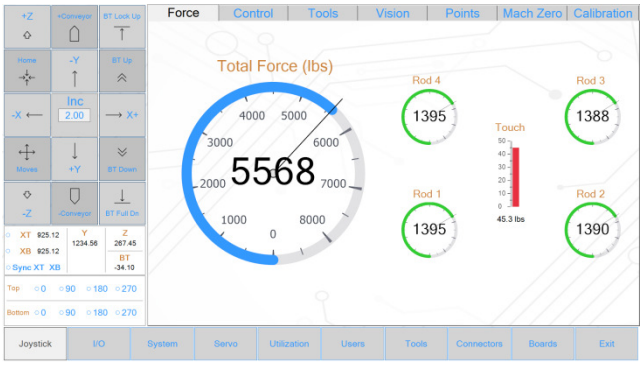


➢**Higher Precision** – High density connectors require more precision both in tool entry into the connector and pressing force. Syneo has taken several steps to improve precision.

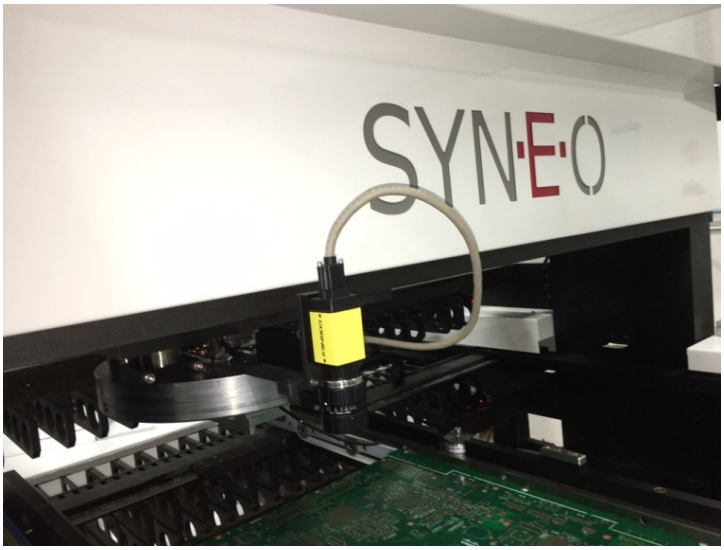
1. Y axis precision – The Y axis table is driven by a belt and was previously positioned with feedback from a linear encoder mounted on the drive belt idler pulley. There were opportunities for position errors due to belt stretch or pitch errors. The upgraded design provides a 1 micron resolution linear encoder mounted directly on the Y axis table. This provides superior position accuracy throughout the life of the press.
2. Upper X axis precision – The upper X axis is driven by a ball screw that was previously positioned using an encoder mounted on the rear shaft of the drive motor. Any lost motion or inaccuracies in the drive system including the timing belt and ball screw would result in pressing tool position error. The upgraded design provides a 1 micron resolution linear encoder mounted inside of the X axis linear rail assembly. This precisely tracks the axis position and avoids errors seen in the prior design.
3. Z axis precision – The Z axis position has always been controlled using a linear encoder but the implementation required a difficult and fussy adjustment and was not as close to the actual head motion as possible. The new design integrates a 1 micron resolution linear encoder into the side of 1 of the 4 guide rods. This provides an easy and stable mount and closely couples with the head motion.

.

4. Load cell precision – The new machine has more than 50X load cell resolution compared with the legacy design and the A/D conversion is done close to the load cells to reduce the possibility of electrical noise. Higher speed force readings allow more effective filtering of any remaining noise.

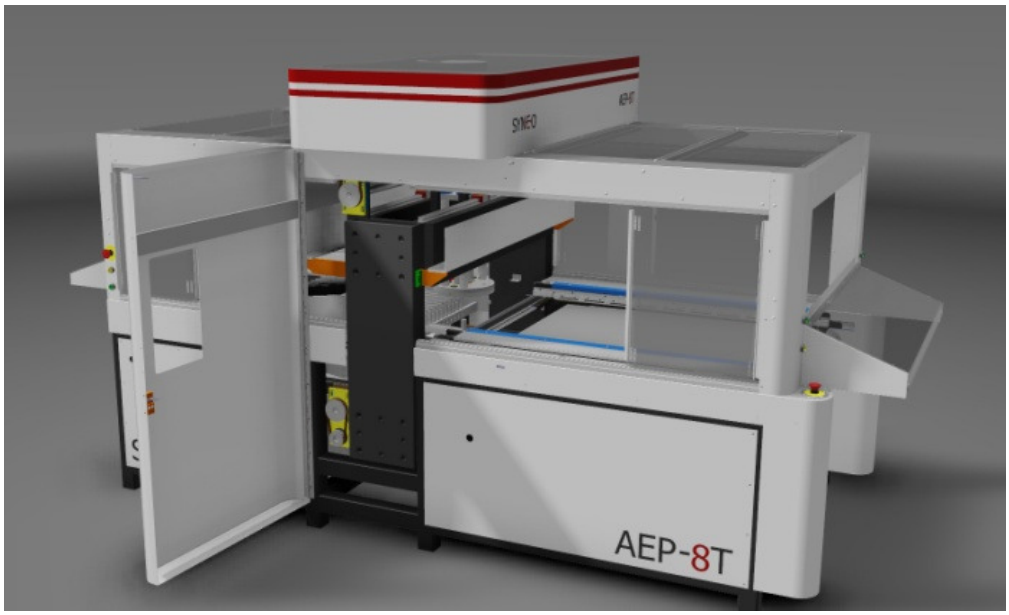


5. Vision system – The vision camera was previously a small field of view, low resolution system with limited capabilities. The upgrade provides a full featured machine vision camera with integrated frame grabber and Ethernet communication to the host PC. This new system is capable of reading 2D and 3D bar codes. Future plans call for using this camera for more functions such as verifying connector location before pressing



- **Obsolescence and maintenance** – Presses designed over 20 years ago have old and obsolete components that are prone to failure. Of primary concern is the computer and servo controller, but there are others as well. Syneo's clean sheet redesign of the controls and software results in machines that will be available and maintainable for many years.
    1. Servo controller – The previous design used a servo controller card mounted inside the PC on the bus. The new PC system communicates to the servo controller via Ethernet. This eliminates many problems with wiring and PC bus obsolescence.
    2. Ethernet – Many wires between the PC and the servo amplifiers had to extend from the back of the PC. The new PC system communicates to all devices via Ethernet daisy chain. This includes communication with the servo controller, servo amplifiers, digital IO, analog IO, vision system, and safety system.
    3. Watchdog – The previous design experienced a few Z-axis runaway conditions which destroyed PCBs and damaged the press. A new watchdog timer device has been added that provides a pulse from the far end of the Ethernet daisy chain to the PC. If the link is broken for any reason or if the PC crashes the safety controller automatically asserts the ESTOP and drops power from all axes and dumps the air from all cylinders. This will protect both the PC and the machine from a variety of potential failures.
    4. Safety controller – The previous design had a number of safety interlocks in series which all had to be properly closed to enable power. If one contact failed it was difficult to determine which one it was. Also, here are 4 ESTOP switches around that machine which must all be released to operate. It was not possible to know which one was pressed without inspecting all of them. The new safety controller integrates all of the interlocks, ESTOP buttons, and watchdog timer into one device which communicates useful information to the PC via Ethernet. This makes verbose status information possible and allows technicians to quickly identify an open door or failed interlock.
    5. Improved accessibility – Access for setup and maintenance has been dramatically improved with larger multi-panel sliding window openings on all sides of the machine. All key electronics have been moved to the sides of the machine so there is no conflict with the buffers which are at the ends of the machine.


6. Improved accessibility – Access for setup and maintenance has been dramatically improved with larger multi-panel sliding window openings on all sides of the machine. All key electronics have been moved to the sides of the machine so there is no conflict with the buffers which are at the ends of the machine.



SYN·E·O
precision tooling & technology solutions

MEP Family of presses

Syneo offers 3 options for manually operated servo electric presses.

Refurbished legacy presses – no obsolete parts, fresh look

Upgraded legacy presses – new condition, new features, 1 year warranty

New presses – new features, 1 year warranty

SYNEO
precision tooling & technology solutions

Refurbished MEP Presses

Refurbished legacy BEMP and MEP presses include the following.

1. New PC & touch screen LCD monitor
2. New servo Ethernet connected servo controller (no more controller inside the PC)
3. New control software with legacy database compatibility
4. Higher resolution A/D force readings
5. New air table and foot switch
6. New paint
7. Replacement of any non-functioning hardware is available and will be quoted on a case by case basis when the machine is being refurbished

Refurbishment is the least costly option to bring legacy presses out of obsolescence. Unfortunately key mechanical parts such as the servo motor, encoder, gearbox, guide rods & bearings, ball screw & bearings, and load cells may be worn to a point that the pressing process is compromised.

SYN·E·O
precision tooling & technology solutions

Upgraded MEP Presses

Upgraded legacy presses include the following:

1. New PC & touch screen LCD monitor
2. New servo Ethernet connected servo controller (controller outside PC)
3. All new electronics and wiring including motor and load cells
4. All new moving mechanical components, (gearbox, ballscrew, bearings, etc)
5. New control software with legacy database compatibility
6. Higher resolution A/D force readings
7. New air table and foot switch
8. New paint
9. **New feature, 2-Stage Force (2SF^{tm}) described below**
10. **New feature, True Distance Measurement (TDM^{tm}) described below**

SYNEO
precision tooling & technology solutions

New Features – 2 Stage Force (2SF^{tm}) (patented)

This new feature improves low end force accuracy and repeatability. Many of the connectors require little force, sometimes less than 10 pounds. In any load cell application the force resolution and accuracy is directly proportional to the maximum force the load cell can measure. Thus, lower ultimate force will always result in better resolution and accuracy. Electrical noise on the A/D circuit (there will always be at least a few millivolts of noise) produces an apparent force proportional to the maximum load cell capacity. Additionally, resolution equals the maximum load cell force is divided by the A/D resolution. Higher ultimate force results in more coarse force resolution. We have developed a 2-stage force measuring system by adding 2 additional load cells and A/D channels. One stage is identical to the current system where the full press force capacity (8 tons) is accommodated. This can be called the high force range. The new range is limited to 1000 pounds and we can call this the low force range. This automatically improves sensitivity and reduces noise by a factor of 16 (16000 pounds / 1000 pounds) when pressing less than 1000 pounds. The implementation is clever in that taking advantage of it is transparent to the user. If the press cycle exceeds 1000 pounds the force monitor will automatically and seamlessly transition from the low range to the high range. If the force required is less than 1000 pounds only the low range load cells will be used to guide the pressing process with dramatic improvement in force resolution and accuracy. It should be noted the user does not need to determine which range will be used and programming the press cycle is identical to the current method. The goal is to accurately press with force in single digit pounds on a 16000 pound capacity press. This new feature will provide significantly better low force accuracy.


SYNEO
precision tooling & technology solutions

New Features – True Distance Measurement (TDM^{tm})

True Distance Measurement (TDM^{tm})
This new feature improves press head position accuracy. There are cases when pressing to a specific height rather than force is the better or even necessary solution. Even when pressing to force it is important to have accurate press head anvil position information. Currently the press head is positioned using an encoder on the motor shaft so in reality it is the motor position that is being controlled rather than the pressing head anvil position. Any inaccuracy in the gearbox, ball screw, or other lost motion cannot be accounted for in this scenario. To overcome these potential errors we have added a linear encoder that directly tracks the head travel. Incidentally, this is the same way the AEP press head has always been controlled. This feature carries added cost but we feel there will be measurable quality improvements.


SYN·E·O
precision tooling & technology solutions

New MEP Presses

Syneo's offering of new presses comparable to the BMEP-5T, MEP-6T, and MEP-12T are the MEP-5TB, MEP-8TM, and MEP-8TL. The MEP-5TB is table top design and presses up to 5 tons of force and has the same table size as the BMEP-5T. The MEP-8TM & 8TL provide the same table sizes as the comparable presses but both press with 8 tons maximum force.

New MEP presses include the following:

1. PC & touch screen LCD monitor
2. Ethernet connected servo controller (controller outside PC)
3. New control software with legacy database compatibility
4. High resolution A/D force readings
5. Air table and foot switch
6. **New feature, 2-Stage Force (2SF^{tm}) dual range load cells**
7. **New feature, True Distance Measurement (TDM^{tm}) 1 micron linear encoder**

SYNEO
precision tooling & technology solutions

Intellectual property rights: All technology developed for or used in equipment sold by Syneo LLC is the exclusive intellectual property of Syneo and may not be used for any other purpose without the expressed written consent of an authorized agent. Any technology that is proprietary to the purchaser of Syneo equipment must be specifically identified with a full description incorporated into the purchasing documents and acknowledged in writing by Syneo at the time of order placement. By placing a Purchase Order for equipment described in this quotation the purchaser acknowledges agreement to this statement.

Confidentiality notice: This document and its contents contain confidential and/or proprietary information and should be treated as such by all recipients. If you are not the intended recipient, please notify the sender and delete immediately.