



Servo Driven Pressing Systems

Global Manufacturing Process

SD-1048

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1. Purpose

To define global guidelines that will provide a common and consistent process for Engineering in all Nexteer regions.

2. Scope

The intent of this specification is to globally standardize the process and requirements for pressing using a servo press. This document is meant to be a baseline for process development and information to include in technical specifications.

3. Process

3.1 Selection

Selection of press type is an essential first step. There are several different types of presses ranging from basic mechanical, pneumatic, hydraulic and servo powered. The amount of control required, data acquisition needs and traceability will typically dictate that a servo press with load and distance control be selected. The remainder of this specification will focus on the guidelines and requirements of pressing with servo control.

3.2 Basic Parameters

Using a servo driven press, Part B (ex: Bearing) will be pressed or pulled into part A (ex: Jacket). The press monitors force and distance, limits are determined based off the print requirements set by product engineering. Method of pressing, i.e. pressing to a force, a distance, rate of change or delta will be determined by the engineer in charge based on the application. Force should be monitored through the whole press sequence and overload limits should be set to protect the part and tooling from damage.

4. Programming

4.1 Pressing Characteristics/New Program

To program a new pressing process, press a part at a slow, constant rate (less than 5mm/s) and observe the graph and use the following characteristics to build the program. Reference Fig 1.

1. Contact Point – The point where the press tooling first contacts the assembly component. At this point the Force vs. Distance graph should begin.
2. Monitoring Window Begin – The monitoring window is used to evaluate the running load (pre-seating) portion of the press curve to ensure the curve behaves in a consistent manner. The monitoring window should begin after the Contact Point. This point is the starting point for capturing the running load (pre-seating) if required.
3. Monitoring Window End – The end monitoring point marks the end of the monitoring window. The Monitoring Window End should be before the Seating Point. This point is the end point for capturing the running load (pre-seating) if required.
4. Relative Lower Limit – A lower limit that runs parallel to the typical press curve. If the press curve crosses the Relative Lower Limit, the curve has acted abnormally, and will automatically

- fail. Relative limits are set based on the application and what is deemed appropriate to the process by the engineer in charge.
5. Relative Upper Limit – An upper limit that runs parallel to the typical press curve. If the press curve crosses the Relative Upper Limit, the curve has acted abnormally, and will automatically fail. Relative limits are set based on the application and what is deemed appropriate to the process by the engineer in charge.
 6. Seating Point – The point where the slope of the graph begins to rapidly increase as the pressed component gets near its final position.
 7. Target Value – The target force or distance value. The cycle is complete when the Target Value is met. The target value is equal to the nominal value of the print required seating force.
 8. Target Value Range - The allowable range for the Target Value per the assembly print.

These are the basics of a pressing program; more sophisticated controls are available in the servo press software. Training modules for these advanced functions are available from the servo press supplier.

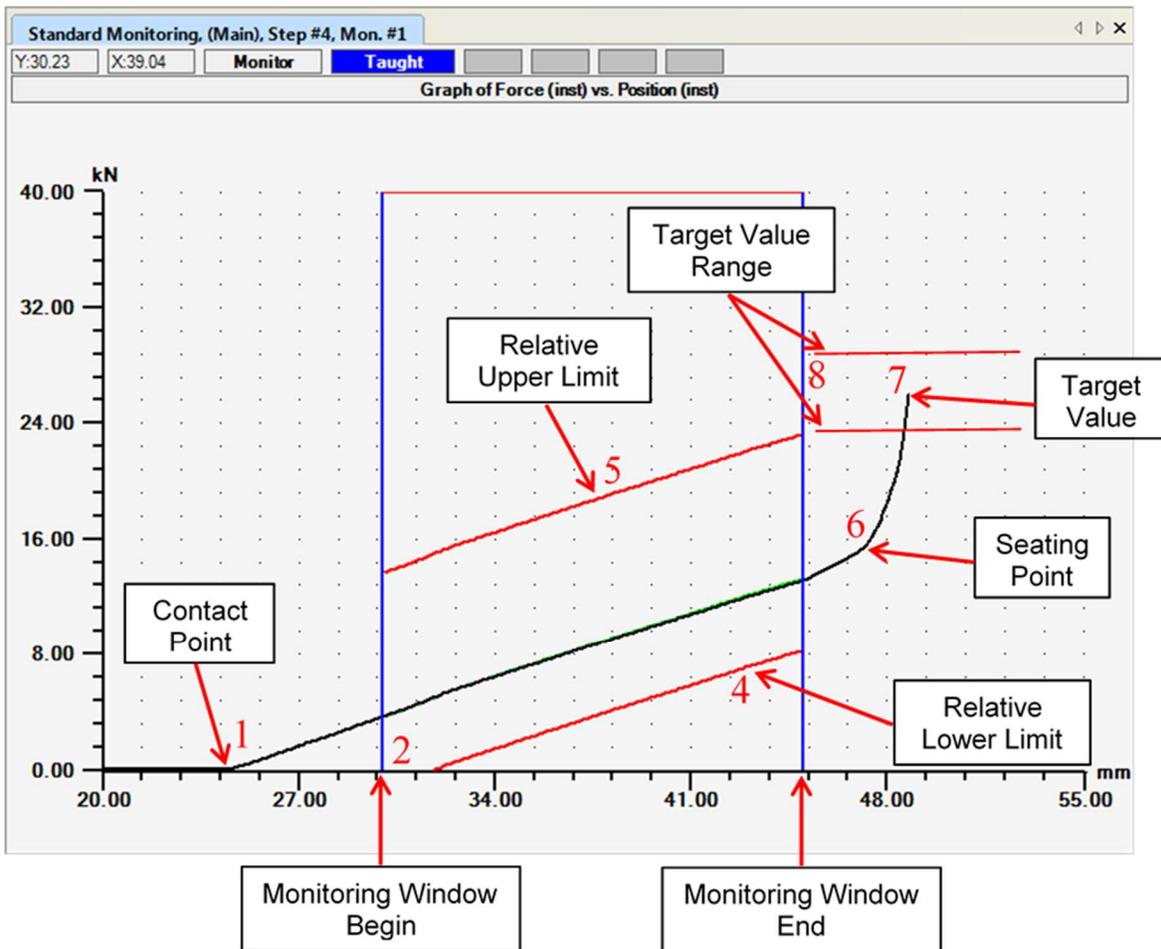


Figure 1 – Pressing characteristics

4.2 Example Software Sequences

4.2.1 Example Press/Pull to Force

- Press to a force is used when the print requires just a force and not controlling a distance. In most cases, distance will be monitored as well. It can also be used to find critical points in the press sequence such as the seating point.
 1. Press rapid moves to initial position above assembly, monitoring overload force for a crash condition.
 2. Press slows down to a very low speed (~1-5mm/s but may be outside this limit based on application) to contact the part and begin pressing components together at a constant speed. At this point the program is targeting the final force and monitoring distance and curve monitors.
 3. When the target force is achieved, the press stops and checks the final distance to ensure it is inside the final distance limits.
 4. Servo program makes decision to accept or reject the part depending on programmed limits for force, distance and curve monitoring.
 5. Press rapid retracts to home position. End of cycle.
- NOTE: Curve monitoring is used in this application to monitor press curve consistency and protect the program from falsely accepting a discrepant part because of inconsistencies in the mating surfaces (burrs, deformation, etc.). The curve is also used to monitor the pre-seating force to ensure the parts have the correct interference fit before bottoming out on the seating surface.

4.2.2 Example Press/Pull to Distance

- Press to a distance is used when the print requires the component that is being pressed to be held to a dimension and you are not just pressing to a shoulder.
 1. Press rapid moves to initial position above assembly, monitoring overload force for a crash condition.
 2. Press slows down to a very low speed (~1-5mm/s but may be outside this limit based on application) to contact the part and begin pressing components together at a constant speed. At this point the program is targeting the final press distance and monitoring force and curve monitors.
 3. When the target distance is achieved, the press stops and checks the final press force to ensure it is inside the press force limits.
 4. Servo program makes decision to accept or reject the part depending on programmed limits for force, distance and curve monitoring.
 5. Press rapid retracts to home position. End of cycle.
- NOTE: Curve monitoring is used in this application to monitor press curve consistency and protect the program from falsely accepting a discrepant part because of inconsistencies in the mating surfaces (burrs, deformation, etc.). The curve is also used to monitor the pre-

seating force to ensure the parts have the correct interference fit before bottoming out on the seating surface.

4.2.3 Example Press/Pull to Seat/Shoulder (Rate of Change)

- Pressing to a rate of change is used when you do not want to put excessive force into a component. Using this method will result in more sporadic seating loads.
 1. Press rapid moves to initial position above assembly, monitoring overload force for a crash condition.
 2. Press slows down to a very low speed (~1-5mm/s but may be outside this limit based on application) to contact the part and begin pressing components together at a constant speed. At this point the program is targeting the specified slope for the force vs distance curve and monitoring distance and pre-seating force.
 3. When the target slope is achieved, the press stops and checks the final distance, final force and pre-seating force to ensure they are all inside their respective limits.
 4. Servo program makes decision to accept or reject the part depending on programmed limits for force, distance and curve monitoring.
 5. Press rapid retracts to home position. End of cycle.
- NOTE: Curve monitoring is used in this application to monitor press curve consistency and protect the program from falsely accepting a discrepant part because of inconsistencies in the mating surfaces (burrs, deformation, etc.). The curve is also used to monitor the pre-seating force to ensure the parts have the correct interference fit before bottoming out on the seating surface.

4.2.4 Example Press/Pull to a Delta

- Press to a delta is used to verify that a component is seated against a shoulder.
 1. Press rapid moves to initial position above assembly, monitoring overload force for a crash condition.
 2. Press slows down to a very low speed (~1-5mm/s but may be outside this limit based on application) to contact the part and begin pressing components together at a constant speed. At this point the program is targeting the seating point (programmed position) and monitoring force and curve monitors.
 3. The seating point is determined based on the application. It can be a dimension on the print or found running multiple parts.
 4. When the seating point is achieved, the press captures the seating force and then adds the specified delta force to seat the component. Example Specification: Press to a force that is greater than the load that is measured during press motion at distance X mm, with max force not to exceed ## kN.
 5. Servo program makes decision to accept or reject the part depending on programmed limits for force, distance and curve monitoring.
 6. Press rapid retracts to home position. End of cycle.

- NOTE: Curve monitoring is used in this application to monitor press curve consistency and protect the program from falsely accepting a discrepant part because of inconsistencies in the mating surfaces (burrs, deformation, etc.). The curve is also used to monitor the pre-seating force to ensure the parts have the correct interference fit before bottoming out on the seating surface.

4.2.5 Example Press/Pull with a Post View Delta

- Press/pulling with a post view delta is used when a component needs to be seated against a blind shoulder. It can be used with other methods, such as pulling to a force, to verify seating. The post view delta is an analysis in the software and does not affect the press/pulling sequence. The sequence below is based on pressing to a force.
 1. Press rapid moves to initial position above assembly, monitoring overload force for a crash condition.
 2. Press slows down to a very low speed (~1-5mm/s but may be outside this limit based on application) to contact the part and begin pressing components together at a constant speed. At this point the program is targeting the final force and monitoring distance and curve monitors.
 3. When the target force is achieved, the press stops and checks the final distance to ensure it is inside the final distance limits.
 4. The press software captures a force at x.xx mm before the target force is achieved and calculates a delta by subtracting that force from the seating/target force. The dimension x.xx and delta force will be set by Product and Manufacturing engineering and is dependent on the process.
 5. Servo program makes decision to accept or reject the part depending on programmed limits for force, distance, delta force and curve monitoring.
 6. Press rapid retracts to home position. End of cycle.
- NOTE: Curve monitoring is used in this application to monitor press curve consistency and protect the program from falsely accepting a discrepant part because of inconsistencies in the mating surfaces (burrs, deformation, etc.). The curve is also used to monitor the pre-seating force to ensure the parts have the correct interference fit before bottoming out on the seating surface.

5. Validation

5.1 MQ Plan

Product / Process Characteristic	Product / Process Specification / Req.	Evaluation Measurement Technique GA-xxxxx TL-xxxxx	Verification Description	MQ Quantity (# of pieces measured)	MQ (Cpk/Ppk) requirements	Gage R&R % / Kappa % CI	Verified (Y/N)	Linearity (Pass / Fail / NA)	CP / CPK Attribute P/F
Seating Force	xx.xx - xx.xx	Servo Load Cell / External Load Cell	Linearity with external load cell	100% of pieces/125 for Capability	See SD-002	N/A	Req	Req	See SD-002
Pre-Seating Force	xx.xx - xx.xx	Servo Load Cell / External Load Cell	Linearity with external load cell	100% of pieces/125 for Capability	See SD-002	N/A	Req	Req	See SD-002
Press Distance	xx.xx - xx.xx	Servo / LVDT	Linearity Study with certified gage blocks	100% of pieces/125 for Capability	See SD-002	N/A	Req	Req	See SD-002
Delta Force	xx.xx - xx.xx	Servo Load Cell / External Load Cell / Software	Linearity with external load cell	100% of pieces/125 for Capability	See SD-002	N/A	Req	Req	See SD-002

Figure 2 - Sample MQ Plan

- The MQ Plan must document the required characteristics that determine the pass and fail criteria for the pressing process.
 - Max & Min Seating Force – The maximum and minimum seating force limits from the assembly print must be included on the MQ Plan. An external loadcell is used to verify the servo press by performing a linearity study. The linearity study is performed near the limits specified by the print.
 - Max and Min Running Load (Pre-Seating Force) (if required) – The maximum and minimum pre-seating force limits from the assembly print must be included on the MQ Plan. An external loadcell is used to verify the servo press by performing a linearity study. The linearity study is performed near the limited specified on the print.
 - Max and Min Seating Distance – The maximum and minimum seating distance limits from the assembly print must be included on the MQ Plan. Calibrated masters with gage blocks or an LVDT are used to verify the servo position by performing a linearity study. The linearity study is conducted near the dimensions that are required by the print. A variable and/or attribute gage shall be used to verify the component is pressed to the correct dimension.
 - Delta Force – The delta force limit(s) from the assembly print must be included on the MQ Plan. Since delta force is calculated by the software, the linearity from the seating and running (pre-seating) force is applicable for verification.
- See Figure 2 for a reference MQ plan. This is a reference only, refer to the process SMD for the most up to date MQ plan. Linearity pass/fail criteria is determined by application. Typical method is a to use a percentage of the rate capacity of the load cell.

6. Quality Control

6.1 PFMEA

- The PFMEA shall document all potential modes and potential causes of each failure mode for the pressing process. All detections shall be verified at design review and qualifications. See the table below for suggestions for potential failure modes and causes of failure.
- The following are suggestions for inclusion in the PFMEA, but the following list should not be considered as a “catch-all”. Each process should be analyzed for all failure modes. Refer to the process SMD for the most up to date PFMEA.

Potential Failure Mode	Potential Causes(s) of Failure
Damaged component while pressing	Broken tooling, worn fixture, misalignment
Not pressed far enough	Part not loaded correctly, press distance not set correctly, load curve not set properly, contamination, cycle interrupted, fixture misalignment
Pressed to far	Press distance not set correctly, contamination, broken detail
Low press load	Insufficient interference
High press load	Excessive interference between components, poor alignment to tooling, loose/worn/missing details, contamination, burrs
Component fell off tooling during operation	Insufficient vacuum pressure, poor alignment
Improper radial orientation of components after press	Component dislodged from tooling during cycle, locating tooling not properly engaged, locators worn or broken
Load cell drifted out of calibration	Load cell was not properly maintained or calibrated in a timely manner

- Reference the PFMEA when creating the MQ Plan to ensure all the detections are listed as evaluation and proper verifications can be performed during the qualification process. See Figure 3 below for an example of a line from the baseline PFMEA and compare how it is reflected in the example MQ Plan and OCP.

Function (Process Step) DO THIS, TO THIS, WITH THIS	Requirement Product / Process Characteristic	Potential Failure Mode	Potential Effect(s) of Failure Mode	SEV	Nexteer Classification	Potential Cause(s) of Failure	Current Prevention Failure Controls	OCC	Planned Detection of Cause (Error) at Source	Planned Detection of Failure Mode (Nonconformance) at Source	Planned Detection of Failure Mode (Nonconformance) Post-Processing
Cycle Press Machine	Press components to assemble in the correct distance with the proper press load	High press load	<ul style="list-style-type: none"> • In Plant: Scrap (7) • Veh Asm: None • Product: None • End User: None 		Std.	Excessive interference between components	<ul style="list-style-type: none"> Process controls at previous operation Supplier process controls 		Upstream gaging	Load cell	

Figure 3 - Sample PFMEA Line

6.2 OCP

- The Operator Control Plan must document the required process controls that evaluate or measure the pass and fail criteria for the pressing process
 - The OCP shall document 1. the evaluation / measurement system being used 2. The procedure or tool that is used to verify proper operation of the evaluation / measurement system and 3. The frequency that verification of the proper operation of the Evaluation / Measurement system for the following pressing characteristics:
 - Max & Min Seating Force
 - Max & Min Running (Pre-Seating) Force
 - Max & Min Seating Distance
- See Figure 4 for a sample OCP. This is a reference only, refer to the process SMD for the most up to date OCP. Verification frequency is based on the application and engineering judgment. One month is used a starting point.

Machine Automated Controls (All 100% Automated)									
Resp	No	Special Class.	Product or Process Characteristic	Prod/Process Specification/Req	Evaluation / Meas. Technique	Verification Description	Verification Frequency	Control Method / Document #	Reaction Plan
			Force	xx.xx - xx.xx	Servo Load Cell / External Load Cell	Calibration / Linearity Study	Once every month		
			Distance	xx.xx - xx.xx	Servo / LVDT	Calibration / Linearity Study	Once every month		

Figure 4 - Sample OCP

6.3 Traceability

- For pressing, the data to be recorded to the traceability system shall be at minimum the data that is recorded on the OCP. It is at the discretion of the engineer in charge if any other data such as pressing speed is included in the traceability data.

6.4 Set-Up Sheets

- The Set-Up Sheets shall document all the required program and machines settings that affect the pressing process. Key program parameters shall be recorded and stored for use if the program is erased and needs to be recreated or if unauthorized alternations are made to the program that need to be returned.
- The following is a list of the minimum that shall be included in the Set-Up sheets for a pressing operation. See Section 4.1 for explanation of the features below.

Feature	Characteristic
Press Speed	Distance and associated speeds (rapid advance, pressing component, rapid return, etc.)
Monitoring Window(s)	Beginning distance, end distance
Running/Pre-Seating Load	Low limit, high limit, monitoring window used
Seating/Target Load	Low limit, high limit, monitoring window used
Delta Torque	Low limit, high limit, monitoring window used, expression used
Press Overload	Overload forces for machine protection
Relative Limits	Low limit, high limit
Rate of Change	Rate of change target, low limit, high limit

7. Calibration

Calibration sequences shall be included in the logic to allow the technician to easily step through the procedure and verify the machine calibration. Number of steps & points is at discretion of the Nexteer engineer in charge with guidance from the receiving plant.

7.1 Force

- Receiving plant must have the capability to check force calibration of the servo press. Typical verification equipment includes a hand-held force gage with display, a load cell appropriate to the application, and any associated tooling. Associated tooling includes nests or masters for the load cell, bushings for “doughnut” load cells, or anything needed to perform the calibration. Calibration frequency is determined by manufacturing engineering with input from press manufacturer.

7.2 Distance

- Receiving plant must have the capability to check distance calibration of the servo press. Typical verification equipment includes Min, Mean, and Max masters and gage blocks/certified spacers. Enough gage blocks/spacers shall be used in order to satisfy the requirements for the linearity study/calibration procedure. Calibration frequency is determined by manufacturing engineering with input from press manufacturer.

8. Linearity

Linearity shall be performed within the print requirement or quality control range and calculated using statistical software. Reference SD-005 and MSA manual for linearity procedure.

RECORD OF REVISIONS

Revision No	Date	Section	Description
001	290C19	ALL	Initial Release
002			
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