E7000 Main Machine
E7000 Main Machine
Tandem X Axis Drive for Best Machine Accuracy
Dual-Drive Gearboxes on Y Axis
Upper Process Head
- Completely open head design for easy access to process tools
Upper Riveting Head

- Linear motor
- Drill spindle
- Drill automatic tool changer
- Sealant inserter
- Resync camera and flushness laser
- Injectors with automatic anvil tool change
- Driver
Upper Head Overview

- Headstone Assembly
- Automatic Tool Changer
- Process tools mounted on a linear motor controlled shuttle table
- Accu-Lube unit
- Automatic fastener injector modules
- Chip vacuum system
Process Tool Layout

- Very fast tool shuttling time
  - 250 ms transition from drill to buck tool
- 244 mm from drill to buck tool
Spindle

Spindle Assembly

- Precise SD60124 E1107 spindle cartridge
- Heidenhain LC495S absolute linear encoder (5 µm accuracy)
- Bosch-Rexroth 20x10R rolled ball screw, size 15 linear bearings
- 1FK7042-2AK71-1CH1 Siemens servo motor with brake (feed axis)
- Self-contained connectorized electrical bulkhead
- A&A Gortite bellows for chip protection
- Easy-access remote greasing for bearings
- Tribos HSK-40E tool holder
SD60124 Spindle Cartridge

- Fischer-Precise SD 60124 spindle with custom housing:
  - AC synchronous, 3-phase, 4-pole motor
  - Speed range of 500 - 20,000rpm
  - 10.1 N-m (89.4 in-lb) nominal torque
  - 17 kW (22.8 hp) at full speed
  - 4 angular-contact, hybrid-ceramic bearings
  - Permanent grease lubrication
  - Dowtherm liquid coolant circulation through housing
  - PTC thermistor and PT100 temperature sensors
  - HSK 40-E clamping system with spring-loaded drawbar (pneumatic release)
  - Integrated PNP proximity sensors to detect tool holder
  - EI has supplied nearly 45 spindle assemblies over 10 projects that use this cartridge

![Graph showing power and torque performance of SD 60124 spindle cartridge](image)
Upper Head Maintenance Access
Upper Head in Maintenance Position
Headstone and Pressure Plate
Upper Pressure Plate

Swappable Nosepiece – no tools needed
Headstone

- Pressure Foot (moves independently from surrounding headstone structure)
- Chip Vacuum Line
- Panel Chip Blow-Off
- (4) Baumer Laser Normality Sensors
Headstone

(4) Air Cylinders control the independent pressure foot

Broken Drill Bit Detection Laser

Compliant Touch-off (drill bit length measurement)

Rivet Length Check Laser

Sealant Inserter
Existing Upper Head Features

Length Check Laser
- Light curtain measures length of rivet/bolt in fingers
- Also senses if rivet is not present

Bomb Bay Doors
- Automatically ejects backwards fasteners or multiple fasteners

Auto Fastener Eject
- Incorrect fastener is automatically rejected
Existing Upper Head Features

**Compliant Touch Off**
- Cutter length measurement
- Prox switch detects touch off and records the cutter length

**Broken Drill Bit Detection**
- Drill bit breaks beam before drill extends to panel
- Automatic feed hold if the drill bit detected is not the correct length

**Air Gap Panel Protection**
- Can detect tipped rivets without damaging the panels
Inside Headstone
Pneumatic Clamp Retracted
Laser Normality Sensors

- Baumer OADM laser distance measuring sensors
- Normalizes panel and maintains constant fly height
- 16-120mm measuring range
Sealant Inserter

- Headstone Mounted
- Pneumatically Controlled Dispense
- Convenient Consumables Management
- Single Cylinder Delivery
Sealant Inserter Headstone Mounting

- Minimal to no impact on cycle time
- Sealant injected during Drill -> Driver shuttle move
- Total sealant cycle time 200-500ms
Broken Drill Bit Detection

Drill bit breaks beam before drill extends to panel
Compliant Touch Off

- Cutter length measurement
- Blue button floats in housing
- Prox switch detects touch off and records cutter length
Fastener Length Verification

- Light curtain measures length of rivet/bolt in fingers
- Also senses if rivet is not present
Fastener Eject

Incorrect fastener is automatically rejected
Rivet/Bolt Driver Tool
Driver

• Design based around the Exlar FT60 series linear actuator
Anvil Socket

Bullet-nose pin ensures correct tool alignment

Tolerates ±8° misalignment during insertion

Ball detent retention mechanism
Air Gap Panel Protection
Air Gap Panel Protection

- Rivet inserter
- Air gap sensor
- Anvil socket
- Rivet anvil
Air Gap Panel Protection

- Air gap sensor
- Anvil socket
- Rivet anvil
- Pressure foot/Clamp pad
Normal Rivet Insertion
Normal Rivet Insertion

Rivet tail inserted into hole correctly
Normal Rivet Insertion

- Air gap remains open
- Sensor does not detect motion
- Fingers release rivet
- Rivet is fully inserted, with face of die contacting the rivet head
Normal Rivet Insertion

Axis drives downward to close the air gap

CNC proceeds with rivet upset cycle
Failed Insertion - Jammed
Failed Insertion - Jammed

Rivet tail hits countersink, jamming between the panel and the die face.
Failed Insertion - Jammed

Air gap remains partially open – only spring force is applied to the tipped rivet (50 lbs / 220 N)

Sensor detects early motion

CNC stops the cycle before panel damage can occur
Failed Insertion - Laid-down

Air gap system also protects against a laid-down rivet
Bolt/Rivet Injector with Integrated Tool Changer
Rivet/Bolt Injector
Injectors & Anvil ATC

Modular injector system holds several injectors for different fastener types and diameters

Servo indexing axis aligns each injector to the driver

Single injector module

Upper anvil tool change is integrated with the injector system
HORIZONTAL RIVETING MACHINE INJECTOR
OVERVIEW

Fastener sent to Injector through feed tubes
Sensor detects fastener’s arrival at Injector
HORIZONTAL RIVETING MACHINE INJECTOR
OVERVIEW

Fastener enters Chamber
HORIZONTAL RIVETING MACHINE INJECTOR
OVERVIEW

Fastener settles in Catch Blocks
Injector Pusher extends and engages fastener’s head and begins pushing towards Fingers
HORIZONTAL RIVETING MACHINE INJECTOR
OVERVIEW

Pusher extends fully and snaps fastener into Fingers
HORIZONTAL RIVETING MACHINE INJECTOR
OVERVIEW

Pusher retracts and Injector is reset for next cycle
Shuttle table moves Driver to drilled hole, injection cycle complete
INJECTOR EJECTION EXAMPLE

Backwards fastener sent to Injector
(Same procedure occurs for multiple fasteners sent, etc.)
HORIZONTAL RIVETING MACHINE INJECTOR
OVERVIEW

Backwards fastener enters Chamber
Backwards fastener settle on Catch Blocks
Pusher attempts to extend but cannot extend due to backwards fastener
(Same happens when multiple fasteners are sent at the same time)
After a timeout which indicates a jam, the Pusher retracts.
HORIZONTAL RIVETING MACHINE INJECTOR
OVERVIEW

Bombay Ejection Doors open and Fastener is blown out
(In the case of multiple fasteners fed, all fasteners are cleared from the Injector at this point)
HORIZONTAL RIVETING MACHINE INJECTOR
OVERVIEW

Bottom view of Injector with Bombay Doors open
HORIZONTAL RIVETING MACHINE INJECTOR
OVERVIEW

Bombay Doors close and Injector is reset to receive the next fastener
Rivet Injector Bomb Bay
Doors Closed

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Electroimpact Proprietary
Bomb Bay Doors Closed
Bomb Bay Doors Open
Resync Camera System

- Macro Lens
- LED Light Ring
- Keyence Flushness Measurement
- Locating Base
- High Resolution Digital Camera
Automatic Resync on Tacks or Drilled holes

- Cognex VisionPro Software
- Color Camera
- Variable LED brightness

Tacks detected even with poor surface conditions
OPTIONAL:
Rivet Flushness Measurement

- High Accuracy Laser displacement sensor
- Red laser with CCD sensor
- 150mm +/- 40mm measurement range
- 0.12mm x 4.2mm beam spot
  - Wide spot reduces surface roughness noise
- 0.25µm repeatability
- Sample rates of 2.5-1000µs (selectable)
- IP 67
- Robust measurement technology
  - high-end optics and controller perform repeatably under varying light and surface conditions
OPTIONAL: Drill ATC
Automatic Drill Tool Changer
Drill ATC

Tool holder slides directly into gripper
ATC Loading

Use buttons to cycle through positions
ATC Loading

Use buttons to cycle through positions
Lower Ram
MAJOR COMPONENTS

- Lower process head assembly
- Z-sled
- Z-axis drivetrain
Lower Tool 1/4in
Lower 1/4in Tool
LOWER PROCESS HEAD

- C axis rotation of +/- 190deg

- Edge margin tracer
- Lower anvil
- Clamp cylinder
- Load cell
- C-axis drivetrain
Lower Process Head
Lower Anvil Tools

- Electroimpact will provide straight tooling and offset tooling for 5/32”, 6/32” & 8/32” riveting
Fastener Feed System

F2C2 fastener feed 16 slot cartridge rack

Cartridge filling station with vibratory bowls
Electroimpact Panel Riveting Dept.

Removable/Adjustable Part Holding Fixture
Picture Frame
Picture Frame

ISO

TOP DOWN

SIDE

END ON
Overview

- Removable Aluminum Frame
- Form Board 4
- Intermediate Form Boards 2 and 3
- Form Board 1
- Machine Interface
- X Index Plates
- Picture Frame Structure
- Machine Interface
Overview

Current ARJ machine part holding fixture
Overview
Flexible Part Holding System

Part Holding adapts to parts
Index Boards and Intermediate Boards slide along the structure
Boards will index to specific locations for different panels
Aluminum frame holds Boards and can be removed from structure

Tapered Panel

Crown Fuse Panel

Largest Panel
Form Board Location Index

Index Plates can be re-machined to add index locations

Form Boards pinoff at index locations
Form Board Location Index

- **Part Marking**
- **Slotted Pinoff Bushings**
- **Mounting Location**
- **Panel Index Designation**
- **X-Index Locating Plate**
- **2x 8mm Index Hole**
  (Corresponds to Index Holes in Picture Frame)
Form Board Overview

- FWD Surface Index
- Edge Index and Clamp
- Sliding Surface Indexes
- Form Board Location Index
- Edge Index and Clamp
Form Board Overview
**Sliding Indexes**

- Each sliding index has multiple index locations for different panel sizes. Each panel style is assigned a letter.
- Plates can be removed and new index locations can be added.
Sliding Indexes move to contact surface

Different index locations for each panel
Edge Index Clamp

- Clamp shown providing index to edge of panel
- Clamp will locate off of edge clamp index plate (shown above)
- Edge clamp index plates can be re-machined to allow for new panels
Edge Index Clamp
Edge Clamp

- Similar clamps will be used on all form boards to clamp the edges of the panel
- Total of 8x per panel
FWD Edge Clamp

Clamps can also be replaced with Lug Indexes depending on customer requirements.
Intermediate Form Board

- Edge Clamp
- Sliding/Retract Surface Indexes
- Form Board Location Index
Intermediate From Boards

Because the intermediate form boards are under the panels, they block hole locations during drilling. They need to be moved after the first machine pass to allow machine to drill all holes.
Sphere Index can be retracted 100mm, while the slider plate remains in position.

This allows the Intermediate board to move while under a panel after first machine pass.
Intermediate Edge Clamp

Edge clamps on these boards also have retract feature

Clamp is now open and retracted, ready for form board to move to next location
Step 1: All index locations are set on an offline frame.
Loading Method

All edge clamps are opened
Panel is loaded into the frame VIA crane or by hand.

Lugs or Edge Indexes can be used to locate in the fixture.
Clamps can now be applied to secure the panel