OP 790 - Auto Install Separator Plate, Feed & Rundown (2) Bolts

OP 790 is a "stand-alone" automatic station in the sense that, although a conveyor runs through it on which parts on pallets are delivered and removed, the conveyor pallet stops are controlled by the OP 790 station controller. Electrical and pneumatic lockouts are provided at the station to enable maintenance personnel to isolate it from the rest of the system and lock it out.

The station consists of the conveyor devices for trafficking and locating the pallet, a bolt feeder, the tooling for selecting a separator plate from one of four stacks and placing it on the pump casting, and the tooling for the powerhead spindles.   The powerhead controls are packaged separately. The station PLC controls the conveyor pallet stops, the station tooling, the bolt feeder, and interlocks to the powerhead controls. A Modicon PanelMate 4000 Series HMI is also provided for operator interface.   The four separator plate stacks allow multiple types of plates to be available, thus providing a limited "flexible build" capability at this station.   The operator selects what plate is loaded onto which stack via the PanelMate HMI. OP 790 has a second RF read / write unit which is located at the station's on-deck pallet stop.   This enables the station to pre-select the correct separator plate prior to the pallet entering the station.   See Fig. 1 below for a conceptual diagram of the station layout and motions.

When a pallet arrives at the station on-deck pallet stop the pallet RF tag is read. If the tag is unable to be read, the pallet is released from in the station, an RF Read/Write Fault is indicated. The part will be operated on if and only if the tag indicates the following:

    (The pallet no. is valid, and
     A part is present on the pallet (i.e. valid build code),)
    - AND -
    (
     (OP 760 accept status bit is set, or
       OP 750 accept status bit is set)
     - AND -
     (OP 770 accept status bit is set, or
       OP 780 accept and OP 770 Assembled status bits are set)
     - AND -
     (OP 780 accept and OP 790 Assembled status bits are not both set (i.e. operation was not   manually
     performed at OP 780))
     - AND -
     (OP 790 complete bit is not set (i.e. operation has not been performed))
)

The separator plates are installed onto the casting in a two-stage process. An overhead three-axis pick-and-place unit (referred to as the "Pick Shuttle") selects a plate from one of the four stacks and places it on the "stage" platform. This first stage is performed when the part type is determined from the RF pallet tag as it is read in the on-deck position. An overhead two-axis pick-and-place unit (referred to as the "Install Shuttle") picks the plate up from the stage platform and deposits it on the part casting. Both of these pick-and-place units utilize an SMC-brand venturi vacuum pump and suction cups to lift the plates. Each has a vacuum switch to sense when a plate is against suction cups.

Following placement of the plate on the part casting, two automatic nutrunner spindles run down two bolts to attach it. If a bolt fails to run down properly on the first try, the nutrunner will back it out and attempt a second run down. If the second attempt fails, the nutrunner will again back it out and flag that bolt as a reject.

Upon completion of the operation, the PLC writes to pallet tag the overall complete / accept status, according to the outcome. If any of the bolts failed to rundown properly after two attempts, failure mode(s) for each bolt is recorded on the tag. The 11-digit part number of the separator plate is also written to the pallet tag. The pallet is released from OP 790 as downstream traffic allows.

Cycle time from part to part is (16) seconds. This includes (4) seconds for pallet trafficking, leaving (12) seconds for operating on the part.

E-stop recovery: If pick shuttle is not raised when E-stop occurs and pick shuttle moves off of prox switches; must recover manually.

A complete list of machine hardware inputs and outputs is provided at the end of this document. Note that all manual functions, position indication, and detailed status indication is accomplished on the touchscreen HMI.

Part vs. Plate Association

Part types are identified with number from 1 to 99. Separator plates are identified with number from 101 to 199. There is no one-to-one correspondence. Each part type can have one and only one separator plate associated with it. Several part types may use the same separator plate. PLC memory contains a lookup table of registers that has one element per part type. The memory register for each part type contains the identification number (101 – 199) of the correct separator plate for that part type. A second lookup table contains a list of eleven-digit ASCII strings for all the separator plates. Once the separator plate is installed on the part the PLC, via the RFID read/write unit, writes this string onto the pallet RF tag.

Stack vs. Plate Association

Each of the four stacks is set independently for which plate it contains. For each stack the PLC maintains a "Displayed Plate Code" memory register and a "Selected Plate Code" memory register. The selection is done via a touchscreen human-machine interface (HMI). For each stack the operator has the ability to scroll through the complete list of separator plates. As the operator scrolls up or down through the list for a given stack, the "Displayed Plate Code" memory register is incremented or decremented respectively between the values of 101 to 199 (i.e. the range of separator plate identification numbers). When the operator arrives at the desired plate, they press a "select" button on the HMI. The PLC then copies the plate number from the "Displayed Plate Code" register into the "Selected Plate Code" register for the stack in question.

Part vs. Stack Association

When a new pallet arrives at the conveyor on-deck pallet stop the PLC, via the RFID read/write unit, reads the part type from the pallet RF tag. The PLC then determines the correct plate code for that part type (described above). Next, the PLC examines each stack's "Selected Plate Code" register to determine if that plate is loaded into any of the stacks and, if so, which one(s). If more than one stack has that separator plate, the PLC directs the tooling to pick from the first such stack.

Machine Sequence

See Fig. 1 below for a conceptual diagram of the station layout, motions, and cylinder descriptions.

I   Selection of separator plate – Automatic Cycle

1) Pallet arrives at conveyor on-deck pallet stop (C4)

2) PLC reads pallet RFID tag and determines a) is valid part type on pallet? b) were previous operations completed successfully on the part? c) which separator plate is required for that part? (see "Part vs. Plate Association") d) which stack, if any, contains the required separator plate (see "Part vs. Stack Association"). Note if pallet does not contain valid part or required plate is not present on any of the stacks, as conveyor traffic allows, the part will be released through the station on not be operated upon. If part is valid and required plate is present, proceed to next step.

3) With Pick Shuttle raised, use C6, C7, C8 to position shuttle's X and Y axes above the stack containing the required plate (see Table 1).

4) Lower Pick Shuttle (Z axis) (C9) until suction cups grip plate (sensed by 10040 Vacuum Switch).

5) Raise Pick Shuttle (Z axis) (C9).

6) Use C6, C7, C8 to position Pick Shuttle's X and Y axes above the plate stage platform (see Table 1).

7) Lower Pick Shuttle (Z axis) (C9) until plate is resting on the stage (indicated by 10053 Proximity Switch).

8) Turn off Pick Shuttle vacuum and turn on Pick Shuttle blow off air to eject plate from suction cups onto stage platform.

9) Raise Pick Shuttle (Z axis) (C9).

10) Use C6, C7, C8 to position Pick Shuttle's X and Y axes above the stack plate was picked from (see Table 1). (It is necessary to remove Pick Shuttle from staging area to make room for Install Shuttle. Best assumption is that next plate required will be same as previous one.)

11) Release pallet from on-deck stop (C4) to in-station stop. NOTE: This action can take place as soon as step (2) is complete AND (there is no pallet in the station OR pallet in station is being release).

12) This process can begin again at step (1) as soon as next pallet arrives at on-deck stop.

II   Installation of separator plate – Automatic Cycle

13) Pallet arrives at conveyor station pallet stop (C11)

14) Read pallet RF tag to confirm (a), (b), and (c) from step (2) above, and to verify that plate on stage is of correct type (stored in PLC memory). If these are true proceed to next step; other wise, release pallet from station as conveyor traffic allows (downstream "high level" switch not on AND previously released pallet has crossed that "high level" switch).

15) Raise Pallet Hi-Lift (C1) to lift and locate pallet.

16) Verify (via 10014 Fiber Optic Switch) presence of spring and T-valve in part. If present, proceed to next step. If not, write to pallet RF tag that part is rejected and release pallet from station as conveyor traffic allows.

17) *While steps (11) – (14) are taking place*, position Install Shuttle (C5) above stage platform.

18) Lower Install Shuttle (C10) until suction cups grip plate (sensed by 10055 Vacuum Switch).

19) Raise Install Shuttle (C10).

20) Position Install Shuttle (C5) above pallet.

21) Lower Install Shuttle (C10).

22) Turn off Install Shuttle vacuum and turn on Install Shuttle blow off air to eject plate from suction cups onto part.

23) Raise Install Shuttle (C10).

24) If Pick Shuttle is clear of stage area (Pick Shuttle has been staging plate for next part), position Install Shuttle (C5) above stage platform.

25) Lower Powerhead Slide (C3).

26) Lower Nutrunner Slide (C2).

27) Issue command to nutrunner system to run down bolts.

28) Receive "accept" or "reject" signal from nutrunner system. Note: if nutrunners fail first attempt, they are programmed to reverse and back bolts out, then try again. If second attempt fails, nutrunner system issues "reject" signal.

29) Raise Nutrunner Slide (C2) and Powerhead Slide (C3).

30) Lower Pallet Hi-Lift (C1) to set pallet back onto conveyor at station pallet stop.

31) Write results to pallet RF tag (overall accept / reject, individual bolt status). If plate was successfully installed, retrieve 11-character plate part number from look up table and write to tag.

32) Release pallet from station as conveyor traffic allows (downstream "high level" switch not on AND previously released pallet has crossed that "high level" switch).

33) Request bolts from bolt feed system.

34) Receive signal from bolt feeder system that bolts are present.

35) This process can begin again at step (13) as soon as next pallet arrives at station pallet stop.

III Load Separator Plates in Stack(s) – Manual Operation

Each plate stack tray is mounted on a slide that is manually pulled out to give the operator access to the stack for loading and unloading plates. Each stack tray has three switches: Stack Empty, Stack in Work Position, and Stack in Load Position.

1) Operator presses "Request Load Stack" button on HMI.

2) And end of current cycle, Install Shuttle Moves to above pallet and Pick shuttle moves to above stage.

3) Operator opens guard door and pulls tray out to load position.

4) Operator fills tray with separator plates.

5) Operator slides tray back into work position and closes guard door.

6) If separator plate type is different from what was in that stack previously, operator selects the new separator plate for that stack on HMI (see "Stack vs. Plate Association" above).

7) Repeat steps (3) through (6) for any other stack(s) to be replenished.

8) Operator presses Start Cycle button on HMI and automatic cycling resumes.

Fig. 1 Conceptual Plan View
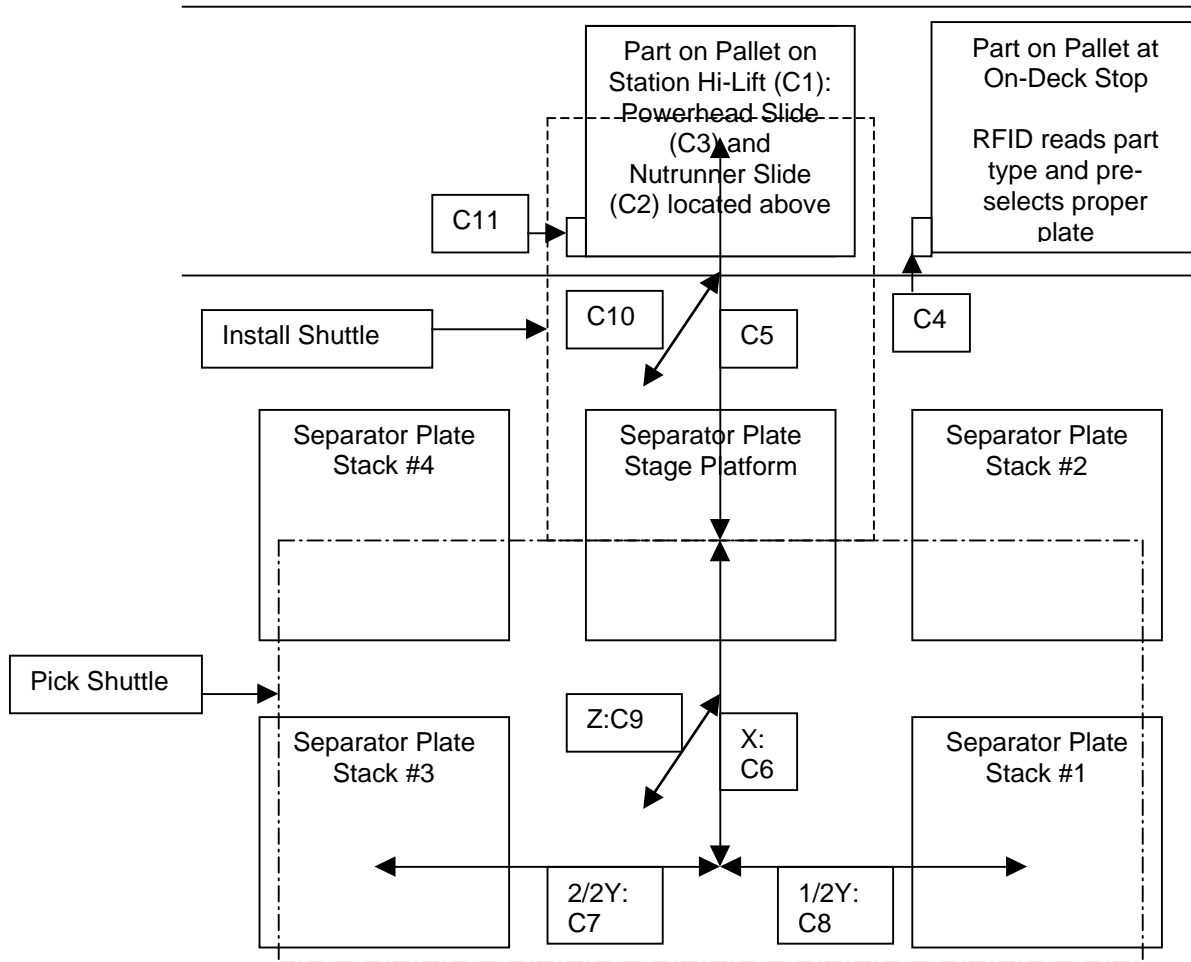
Tooling Cylinders are described as follows:

C1   Pallet Hi-Lift (vertical - lifts pallet off of conveyor and locates within station)

C2   Nutrunner Slide (vertical – moves entire powerhead slide to contact with part)

C3   Powerhead Slide (vertical – moves individual powerheads as bolts are run down)

C4   On-Deck Pallet Stop ("flipper" style – lowers to release pallet from on-deck into station)

C5   Separator Plate Install Shuttle (horizontal – moves between separator plate "stage" and pallet)

C6   Pick Shuttle X (horizontal – x-axis - moves between Stacks #1/#3 and Stacks #2/#4/Stage)

C7   Pick Shuttle Y2 (horizontal – 2/2 y axis - when C8 is ext'd, moves between Stage and Stacks #3/#4)

C8   Pick Shuttle Y1 (horizontal – 1/2 y axis - when C7 is ret'd, moves between Stacks #1/#2 and Stage)

C9   Pick Shuttle Z (vertical – raises separator plates from stack(s) & lowers onto stage)

C10   Separator Plate Install Shuttle (vertical – raises separator plates from stage & lowers onto part on pallet)

C11   In-Station Pallet Stop ("flipper" style – lowers to release pallet from station to downstream conveyance)

Table 1   Pick and Install Shuttles' Cylinder Positions

Move to Target Position:	Cylinder number and action required					
	C5	C10	C6	C7	C8	C9
Pick Shuttle above Stack #1	Don't Care	Don't Care	Retract	Retract	Retract	Retract (Raise)
Pick Shuttle above Stack #2	Don't Care	Don't Care	Extend	Retract	Retract	Retract (Raise)
Pick Shuttle above Stack #3	Don't Care	Don't Care	Retract	Extend	Extend	Retract (Raise)
Pick Shuttle above Stack #4	Don't Care	Don't Care	Extend	Extend	Extend	Retract (Raise)
Pick Shuttle above Stage	Retract (over pallet)	Don't Care	Extend	Retract	Extend	Retract (Raise)
Pick Shuttle on Stack #1	Don't Care	Don't Care	Retract	Retract	Retract	Extend (Lower)
Pick Shuttle on Stack #2	Don't Care	Don't Care	Extend	Retract	Retract	Retract (Lower)
Pick Shuttle on Stack #3	Don't Care	Don't Care	Retract	Extend	Extend	Retract (Lower)
Pick Shuttle on Stack #4	Don't Care	Don't Care	Extend	Extend	Extend	Retract (Lower)
Pick Shuttle on Stage	Retract (over pallet)	Don't Care	Extend	Retract	Extend	Retract (Lower)
Install Shuttle above Stage	Extend	Retract	C6, C7, and C8 must be positioned anywhere *except* above or on stage			Don't Care
Install Shuttle above Pallet	Retract	Retract	Don't Care	Don't Care	Don't Care	Don't Care
Install Shuttle on Stage	Extend	Extend	C6, C7, and C8 must be positioned anywhere *except* above or on stage			Don't Care
Install Shuttle on Pallet	Retract	Extend	Don't Care	Don't Care	Don't Care	Don't Care

Machine Inputa
Note: All Manual controls and separator plate specification for stacks are accomplished via HMI.

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Non-Motion Inputs (Mode selection, etc.)
Motion Position Sensor Inputs
Bolt Feeder Subsystem (treat as separate module)
Nutrunner Subsystem (treat as separate module)
Unused Inputs
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10001	MASTER	POWER ON	314 CRM			
10002	MOTION	POWER ON	332 CR			
10003	OP 790	GUARD #1	OPENED	10003 LS		
10004	OP 790	GUARD #2	OPENED	10004 LS		
10005	STATION AIR	ON	10005 PS			
10006	OP 790	GUARD #3	OPENED	10006 LS		
10009	OP 790	PALLET	PRESENT	ON DECK	10009 PRS	
10010	OP 790	PALLET	PRESENT	10010 PRS		
10011	OP 790	HI-LIFT	RAISED	10011 PRS		
10012	OP 790	HI-LIFT	LOWERED	10012 PRS		
10013	OP 790	DOWNSTREAM	HIGH LEVEL	10013 PRS		
10014	OP 790	SPRING /	T-VALVE	PRESENT	10014 FOS	
10017	OP 790	STACK #1	AT LOAD	POSITION	10017 PRS	
10018	OP 790	STACK #1	AT WORK	POSITION	10018 PRS	
10019	OP 790	STACK #1	EMPTY	10019 PRS		
10020	OP 790	STACK #2	AT LOAD	POSITION	10020 PRS	
10021	OP 790	STACK #2	AT WORK	POSITION	10021 PRS	
10022	OP 790	STACK #2	EMPTY	10022 PRS		
10025	OP 790	STACK #3	AT LOAD	POSITION	10025 PRS	
10026	OP 790	STACK #3	AT WORK	POSITION	10026 PRS	
10027	OP 790	STACK #3	EMPTY	10027 PRS		
10028	OP 790	STACK #4	AT LOAD	POSITION	10028 PRS	
10029	OP 790	STACK #4	AT WORK	POSITION	10029 PRS	
10030	OP 790	STACK #4	EMPTY	10030 PRS		
10034	OP 790	SEP. PLATE	PICK SLIDE	RAISED	10034 PRS	
10035	OP 790	PICK SHUTTLE	CYLINDER 8	EXTENDED	10035 PRS	
10036	OP 790	PICK SHUTTLE	CYLINDER 8	RETRACTED	10036 PRS	
10037	OP 790	PICK SHUTTLE	CYLINDER 7	EXTENDED	10037 PRS	
10038	OP 790	PICK SHUTTLE	CYLINDER 7	RETRACTED #1	10038 PRS	
10039	OP 790	PICK SHUTTLE	CYLINDER 7	RETRACTED #2	10039 PRS	
10040	OP 790	PICK SHUTTLE	VACUUM ON	10040 VS		
10041	OP 790	PICK SHUTTLE	CYLINDER 6	EXTENDED	10041 PRS	
10042	OP 790	PICK SHUTTLE	CYLINDER 6	RETRACTED	10042 PRS	
10043	OP 790	SEP. PLATE	STACK	LOW LEVEL	10043 PRS	
10045	OP 790	INSTALL	SHUTTLE	ADVANCED	10045 PRS	
10046	OP 790	INSTALL	SHUTTLE	RETURNED	10046 PRS	
10047	SEP. PLATE	INSTALL	SHUTTLE	SLIDE RAISED	10047 PRS	
10048	SEP. PLATE	INSTALL	SHUTTLE	SLIDE LOWERD	10048 PRS	
10049	OP 790	NUTRUNNER	SLIDE	LOWERED	10049 PRS	
10050	OP 790	NUTRUNNER	SLIDE	RAISED	10050 PRS	
10051	OP 790	POWERHEAD	SLIDE	LOWERED	10051 PRS	
10052	OP 790	POWERHEAD	SLIDE	RAISED	10052 PRS	
10053	OP 790	SEP. PLATE	PRESENT	ON STAGE	10053 PRS	
10055	OP 790	INSTALL	SHUTTLE	VACUUM ON	10055 VS	
10057	2-BOLT	FEEDER	OVERLOAD	TRIPPED	00041 MOL	
10058	2-BOLT	FEEDER	AIR ON	10058 PS		
10059	2-BOLT	FEEDER	HOPPER LOW	LOW LEVEL	10059 PRS	
10060	2-BOLT	FEEDER	TRACK 1	LOW LEVEL	10060 PRS	

10061	2-BOLT	FEEDER	TRACK 2 LOW	LEVEL	10061 PRS	
10129	INTELLECT	POWER ON	(INTERLOCK	FROM I-R)		
10130	INTELLECT	READY	(INTERLOCK	FROM I-R)		
10131	I-R	ACCEPT	(INTERLOCK	FROM I-R)		
10132	I-R	CYCLE	COMPLETE			
10135	SPINDLE #1	HIGH TORQUE	(INTERLOCK	FROM I-R)		
10136	SPINDLE #1	LOW TORQUE	(INTERLOCK	FROM 1-R)		
10137	SPINDLE #1	HIGH ANGLE	(INTELOCK	FROM I-R)		
10138	SPINDLE #1	LOW ANGLE	(INTERLOCK	FROM I-R)		
10139	SPINDLE #2	HIGH TORQUE	(INTERLOCK	FROM I-R)		
10140	SPINDLE #2	LOW TORQUE	(INTERLOCK	FROM I-R)		
10141	SPINDLE #2	HIGH ANGLE	(INTERLOCK	FROM I-R)		
10142	SPINDLE #2	LOW ANGLE	(INTERLOCK	FROM I-R)		

Machine Outputa

Note: All position indicators and separator plate selections for stacks are accomplished via HMI.

Non-Motion Outputs (Status indicators, etc.)
Machine Motion Outputs
Bolt Feeder Subsystem (treat as separate module)
Nutrunner Subsystem (treat as separate module)
Unused Outputs

00001	STATION	AUTO CYCLE	STACK	00001 LT	(GREEN)	
00002	STATION	IN MANUAL	STACK	00002 LT	(AMBER)	
00003	STATION	FAULT	STACK	00003 LT	(RED)	
00004	STATION 3	CONSECUTIVE	REJCTS STACK	00004 LT	(BLUE)	
00005	STATION	AUDIBLE	ALARM	00005 AH		
00009	OP 790 LOWER	ON DECK	PALLET STOP	00009 SOL		
00010	OP 790 LOWER	IN STATION	PALLET STOP	00010 SOL		
00011	OP 790	RAISE	HI-LIFT	00011 SOL		
00012	OP 790	LOWER	HI-LIFT	00012 SOL		
00013						
00015						
00016						
00017	OP 790 LOWER	SEP. PLATE	PICK SLIDE	00017 SOL		
00018	OP 790 RAISE	SEP. PLATE	PICK SLIDE	00018 SOL		
00019	OP 790	PICK SHUTTLE	EXTEND	CYLINDER 6	00019 SOL	
00020	OP 790	PICK SHUTTLE	RETRACT	CYLINDER 6	00020 SOL	
00021	OP 790	PICK SHUTTLE	EXTEND	CYLINDER 7	00021 SOL	
00022	OP 790	PICK SHUTTLE	RETRACT	CYLINDER 7	00022 SOL	
00023	OP 790	PICK SHUTTLE	EXTEND	CYLINDER 8	00023 SOL	
00024	OP 790	PICK SHUTTLE	RETRACT	CYLINDER 8	00024 SOL	
00025						
00026						
00029	OP 790	SEP. PLATE	INSTALL	VACUUM	00029 SOL	
00030	OP 790	SEP. PLATE	INSTALL	BLOW OFF	00030 SOL	
00031	OP 790	SEP. PLATE	PICK VACUUM	OFF	00031 SOL	
00032	OP 790	SEP. PLATE	PICK	BLOW OFF	00032 SOL	
00033	OP 790	LOWER	POWERHEAD	SLIDE	00033 SOL	
00034	OP 790	RAISE	POWERHEAD	SLIDE	00034 SOL	
00035	OP 790 LOWER	NUTRUNNER	SLIDE	00035 SOL		
00036	OP 790 RAISE	NUTRUNNER	SLIDE	00036 SOL		
00037	OP 790 LOWER	SEP. PLATE	INSTALL	SLIDE	00037 SOL	
00038	OP 790 RAISE	SEP. PLATE	INSTALL	SLIDE	00038 SOL	

00039	OP 790 ADV.	INSTALL	SHUTTLE	TO STAGE	00039 SOL	
00040	OP 790 RET.	INSTALL	SHUTTLE TO	PART	00040 SOL	
00041	BOLT	FEEDER RUN	ELEVATOR	MOTOR	00041 MS	
00042	BOLT	FEEDER CLEAR	TRACK	00042 SOL		
00043	BOLT FEEDER	ADVANCE	ESCAPEMENT	00043 SOL		
00044	BOLT FEEDER	BOLTS REQ'D	BEACON	00044 LT	(YELLOW)	
00045	BOLT FEEDER	BLOW BOLTS	00045 SOL			
00046	BOLT FEEDER	RETURN	ESCAPEMENT	00046 SOL		
00049						
00062						
00065						
00066						
00067						
00068						
00069						
00070						
00071						
00072						
00073						
00074						
00075						
00076						
00077						
00078						
00079						
00081	I-R	AUTOMATIC	SELECTED			
00082	I-R	MANUAL	SELECTED	(INTERLOCK	TO I-R)	
00083	I-R CYCLE	NUTRUNNER	(INTERLOCK	TO I-R)		
00084	I-R	FREE SPEED	SELECT	(INTERLOCK	TO I-R)	
00085	I-R SLOW	SPEED SELECT	(INTERLOCK	TO I-R)		
00086	I-R RUN	FORWARD	(INTERLOCK	TO I-R)		
00087	I-R RUN	REVERSE	(INTERLOCK	TO I-R)		
00094	I-R	ASSEMBLY #1	SELECT	(INTERLOCK	TO I-R)	
00095	I-R	ASSEMBLY #2	SELECT	(INTERLOCK	TO I-R)	
00096	I-R	ASSEMBLY #3	SELECT	(INTERLOCK	TO I-R)	