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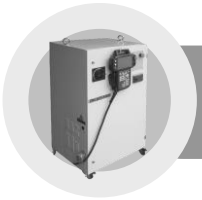
Hyundai Robot

Hi5PA121001FMEN2



Hi5 Controller Function Manual

Palletize

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1 Overview

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Palletize Function means creating new target point to load workpieces regularly according to standardized pattern after picking up workpieces from a conveyor or fixed jig. And it can be divided as Palletize Operation and Depalletize Operation.

1.1. Palletizing & Depalletizing

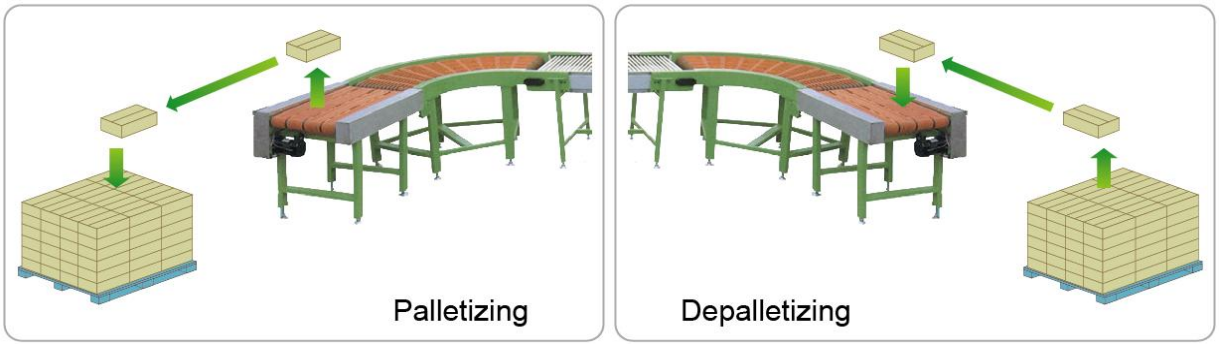

Figure 1.1 Palletizing / Depalletizing

Figure 1.1 shows the example of Palletizing & Depalletizing Flow.

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Reference

- **What is palletizing?**
  It means picking up and move workpieces at a certain position into a standardized pattern.
- **What is depalletizing?**
  It means moving the workpieces stacked up in a standardized pattern to a certain position.

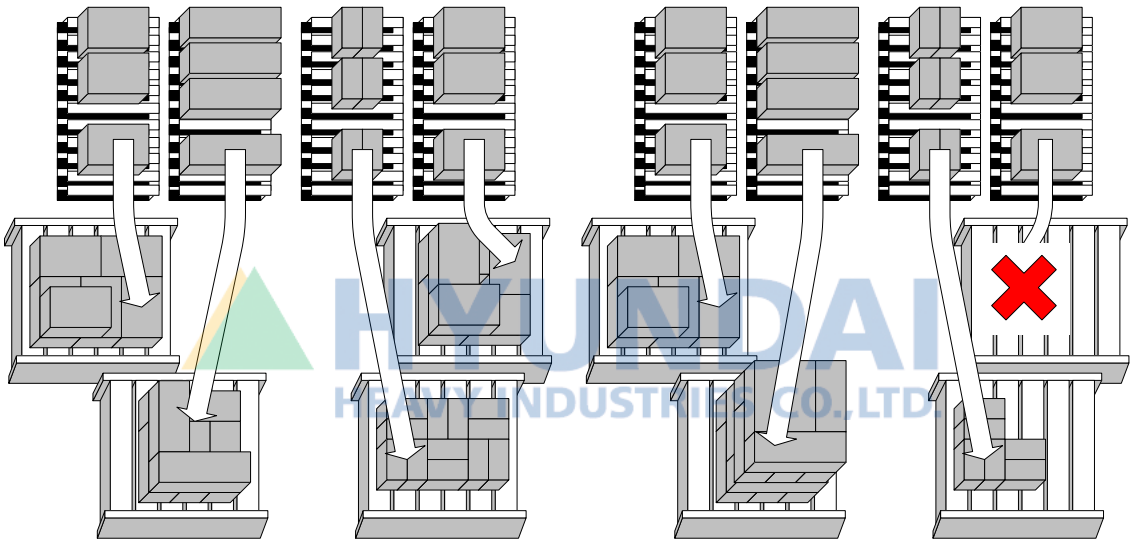
1.2. Specification

1.2.1. Duplicate Processing

- If there are several pallets, you can load them simultaneously.
- You can load pallets of maximum 16 units within robot motion range.

1.2.2. Multiprocessing

- While loading simultaneously several pallets, you cannot load preferentially a certain pallet.



Duplicate processing Function Multiprocessing Function

Figure 1.2 Duplicate processing/Multiprocessing

Program 1Cycle duplicates processing Program 1Cycle multiprocessing

Figure 1.3 Program 1cycle Duplicate processing /Multiprocessing Function

※ Note

- **What is palletizing?**
  It means picking up and move workpieces at a certain position into a standardized pattern.

- **What is depalletizing?**
  It means moving the workpieces stacked up in a standardized pattern to a certain position.

Reference

- Duplicate processing Function ⊃ Multiprocessing Function
  (It shows Multiprocessing is a part of Duplicate processing.)

- If a program is composed of (PAL, PALEND), (PAL, PALEND) command sequentially …, the operation of the sequence is possible.

- If a program is composed of (PAL, PAL…, PALEND, PALEND…) command sequentially, the operation of the sequence is impossible.

※ PAL command means 『Palletizing-Shift』 PALEND command means 『Palletizing-End.』

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1.2.3. Basic Function

(1) Palletizing

(2) Depalletizing

(3) Pickup Position Changing about the different type (the size is different) of workpieces.

(4) As the function that automatically decides the location of the avoidance step after picking up the work piece, this function decides the height of the avoidance step considering the height of the layer to put the work piece.

(5) Height deviation by weight or volume function by workpiece mass or volume.

(6) Pallet slope Measuring Function

(7) Loading Order Change Function by the approach direction.

(8) Rotational loading for even number layer based on odd number layer pattern.

(9) Tier-sheet Insertion Function

(10) Workpiece lineup (Outline or Center) Function

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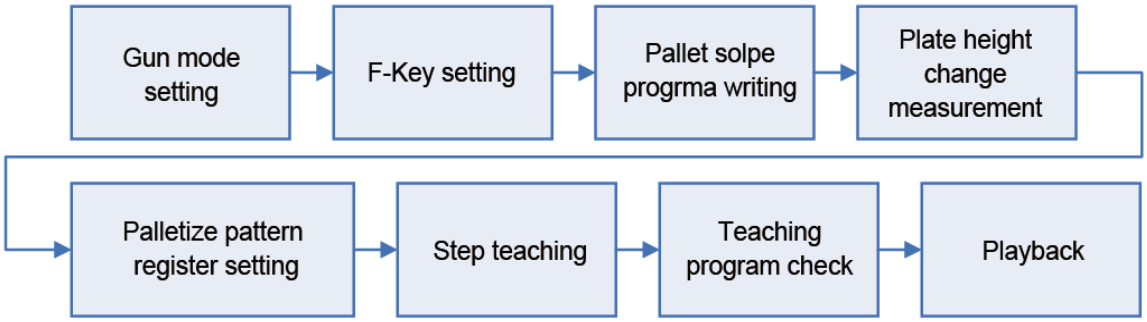
1.3. Palletizing Operation Flow

The Palletizing process is executed as follows.



(1) Refer to Usage Setting.

(2) See F-Key setting.

(3) See Pallet slope program writing.

(4) Measure the layer height change by the mass or volume of workpiece and then find the mean value.

(5) See Palletize pattern register setting.

(6) See Step teaching.

(7) Check Teaching program.

(8) See Playback.

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1.4. Getting started Teaching

Before you begin Teaching, you should set up below operation.

(1) Check whether Valid is set for Palletize at Usage Setting. If not, the Palletize function cannot be applied.

(2) Check F-Key setting which is correct.

(3) Check written Pallet slope measuring program.

(4) If there is an tier-sheet, please check written tier-sheet inset program.

(5) Check Palletize pattern register setting value which is correctly inputted.

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1.5. Glossary (Palletizing Function related)

(1) Palletize Pattern Register
To perform Palletizing, this is the register inputting necessary data.

(2) No.of Workpiece/level
To load it on one layer, this is the number of workpieces.

(3) Pattern number.
To distinguish workpiece loading type (shape), this is number.

(4) Workpiece formation
This means Workpiece formation Method.

(5) Total stacking level
This means total layers loading workpieces.

(6) Even level pattern rotation
On the basis of add numbers' layers, this means rotation (angle) unloading even numbers' layers.
According to rotation angle, the loading order for workpieces is changed.

(7) Approach direction
Just before unloading the workpiece on a pallet, the incoming direction of step is Approach direction.
According to incoming direction, the loading order is decided.

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(8) Height deviation by weight or volume
If the layer height is changed because deformation is occurred by workpiece mass and volume etc., this means offsetting the deviation.

(9) Height deviation by weight or volume
This means the layer to begin deviation offset.

(10) Sag or swell value
This means the mean value of layer height change.

$$Sag\ or\ swell\ value(MdH) = \frac{Calculated\ loading\ height\ (Hideat) - Field\ measuremen\ t\ height\ (Hreal)}{Total\ stacking\ level - Beginning\ applicatio\ n\ for\ change\ amount\ applicatio\ n}$$

MdH : **M**ean value **D**elta of the **H**eight-deviation
Calculated loading height (Hideat) = Workpiece height (H) × the number of total layers
Field measurement height (Hreal): Loading height measured by measuring tape or other measuring gadgets

(11) K(constant)
This is K (constant) value offsetting change amount (linear or non-linear) of layer height deviation.

(12) Pallet rotation slope
This means the dip that the pattern is configured to the center of robot coordinate system, and this is Pallet slope because Pallet and Pattern are paralleled.

(13) Picking-up
This means the activity picking up & lifting up an workpiece from fixed jig or conveyor.

(14) Picking
This means the activity picking up an workpiece from fixed jog or conveyor.

(15) Tier-sheet
This means the paper inserting it between layers when the layer is changed during loading workpieces, insulting paper or damp proof paper.

(16) Inserting Tier-sheet
This means the activity inserting a Tier-sheet between layers.

(17) Tier-sheet Insert
This means the standard to decide the interval to insert Tier-sheets.

(18) The last Tier-sheet insert
Decide to insert the last Tier-sheet or not.

(19) Fine Adjustment
This means that the user creates wanted position data optionally and controls it by reflecting micro shift amount (dX, dY, dZ) on position data automatically created by Palletize Function.

(20) Palletize Count
This means the number of current processing workpieces (count).

(21) PALCNT
This command is Palletizing counter.

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2
System Setting

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2.1. Setting of Usage, User Key Initialization and Input/output Signal Initialization

(1) Select『[F2]: System』 → 『5: Initialize』 → 『3: Usage setting』.

(2) Set “Enable” for “Palletizing”, and set “Palletizing” for “User key init” well as for “In/Out assign init”.

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※ Attention

- If “Palletizing” is not set at Usage Setting, the palletizing function cannot be used.
- When it comes to the change of the function at the Usage Setting, it can be possible only after entering the engineer code.
- After the usage is selected, push the『[F7]: Complete』key

2.2. Palletize Pattern Register Setting

2.2.1. How to control

(1) To input Palletize Operation Information, select 『[F2]: System』 → 『4: Application Parameter』 → 『3: Palletizing』 → 『1: Palletize Pattern Register』.

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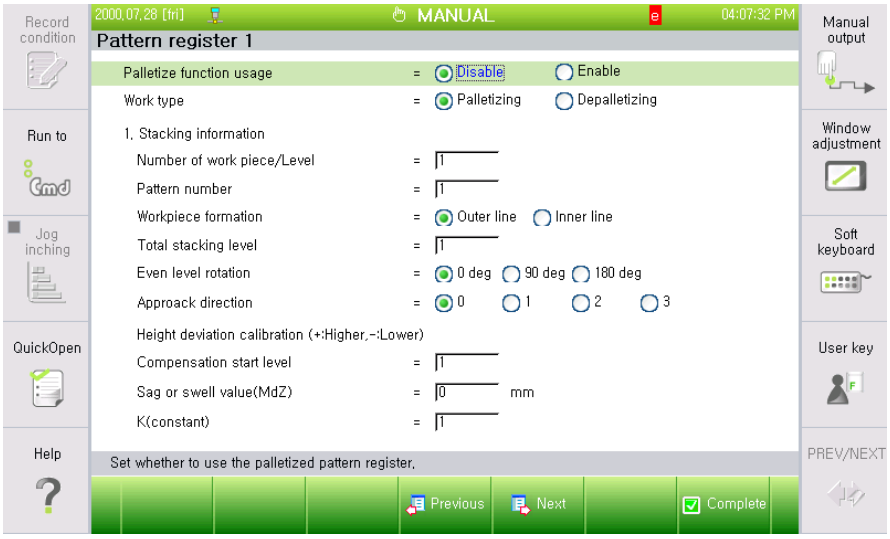
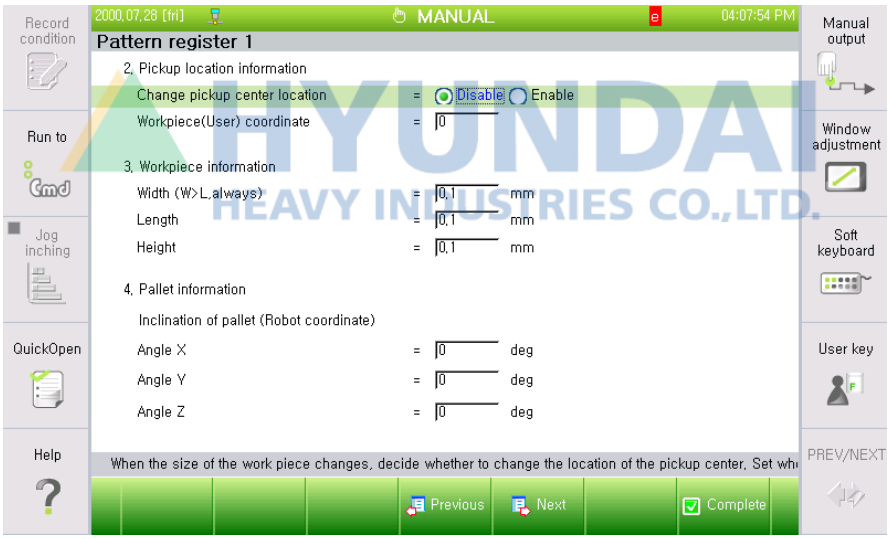
(2) If you set up one of 16 Pattern Registers, you can see below screens.





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2.2.2. Palletize Pattern Register

This is to enter the workpieces and the work environment in order to implement the Palletize function. Entering the information is essential to use the Palletize function. You can save Palletize 『Pattern Register』 of maximum 16units.

The part marked as the shadow of < ■ , > and the value set up as [ ] means initial value.

(1) Palletize function usage = <Disable, Enable>
You can decide to use register to use or not at the moment. If you want to use Palletize Function, you must set up it as Used.

(2) Work type = <Palletizing, Depalletizing >
You can decide to apply Palletizing or Depalletizing.

(3) Number of Workpiece/Level = [1]
This means the total workpiece units of a layer and maximum 25 units can be loaded on a layer. And set up wanted units of which setting range is 1 to 25. See Figure 2.2.

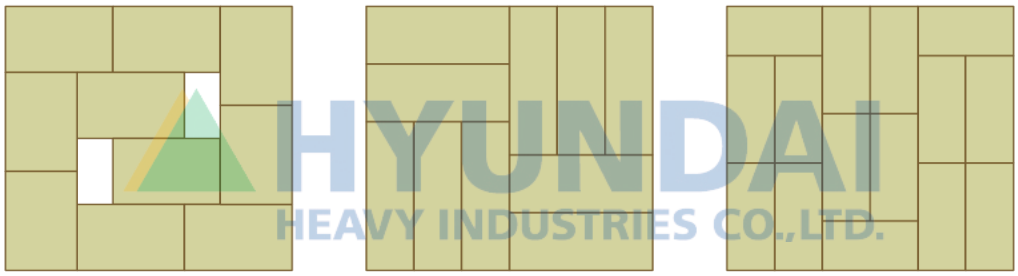


Figure 2.1 Number of Workpiece/Level

※ Attention

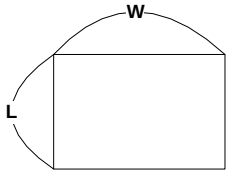
- Between current workpiece units, some of them are not applied and if there is a request, it can be reflected.

(4) Pattern number=[1]
Pattern No. distinguish loading type and it has patterns of other 6 units. Set up Pattern No. of wanted type. Setting range is 1 to 6.

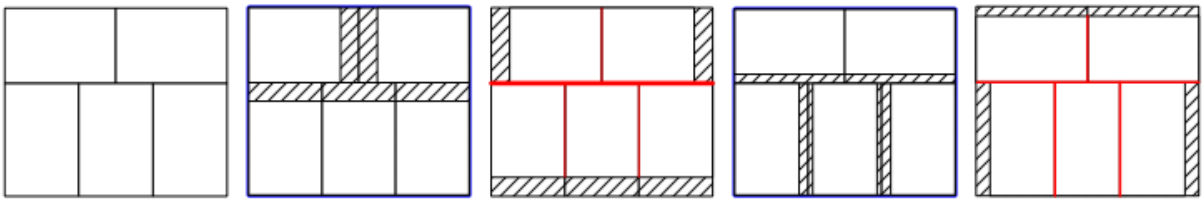
※ Attention

- Between current patterns, some of them are not applied and if there is a request, it can be reflected.

(5) Workpiece formation = < Outer line, Inner line >
Pattern Configuration Type means when configuring pattern, this is setting item where to reflect offset amount occurred by workpiece size rate (the rate of width and length of the workpiece). Here offset amount means the interval between workpieces. In Palletize Function, create the amount and decide reflected part according to setting value.



For example, to configure (a) pattern of Figure 2.2, the pattern which is the same as (a) pattern of Figure 2.2 when the workpiece size rate is Wide: Length = 3:2. And if the rate of workpiece is not the same, pattern types (b), (c), (d), (e) of Figure 2.2 can be configured and the pattern of other types can be configured by user's setting.



(a) 2W=3L (b) 2W<3L (c) 2W<3L (d) 2W>3L (e) 2W>3L

Figure 2.2 Workpiece Size Rate to configure pattern

In case of **Outline Arrangement** (arranged by out of blue line), the patterns are configured as (b), (d) type of Figure 2.2, In case of **Center Arrangement** (arranged by the center of red line), the patterns are configured as (c), (e) type of Figure 2.2.

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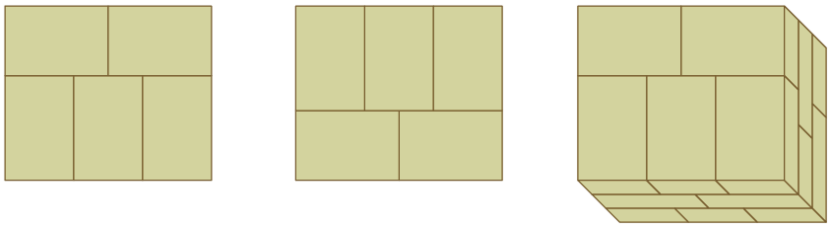
(6) Total stacking level = [1]
This sets up total layer units to load. The maximum value to set up is 100.
Setting range is 1 to 100.

(7) Even level rotation = < 0, 90, 180 > degree
To prevent collapse of workpieces, it rotates the total pattern properly on even number layers and then it loads them. Even number layers can be rotated as 0, 90,180 degree against basic pattern. Generally, even number layers are loaded by 180-degree rotation against even number layers.



(a) Basic pattern (b) 180° Rotation pattern (c) Loaded type

Figure 2.3 Even number layers' rotation angle

Reference

- For example, when you set up (a) pattern of Figure 2.3, even number patterns can be rotated as 0°, 90°, 180° on the basis of (a) of Figure 2.3. (b) of Figure 2.3 shows (a) pattern of Figure 2.3 and (c) of Figure 2.3 shows the process of loading workpieces.

(8) Approach direction = <0, 1, 2, 3>
When stacking workpieces, this decides Approach direction to decide loading order.

The reason why decide operation order by setting up Approach direction,

- ✓ When stacking workpieces, this is to avoid the interruption between workpieces.
- ✓ Also, this is to avoid the interruption by handling tool.

For Approach direction Selection, this is a rule to select reverse direction of workpieces to be performed initially.

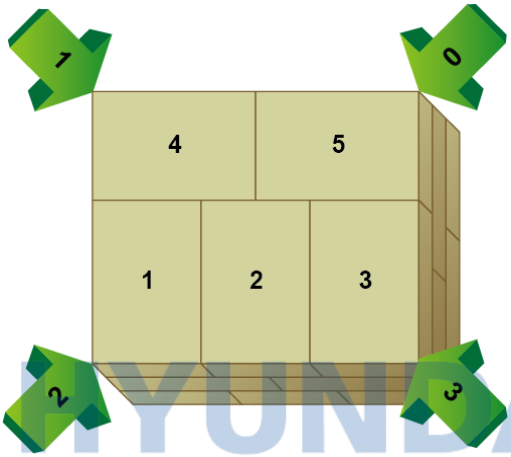


Figure 2.4 Approach direction Selections

One of the 4 loading sequences can be selected depending on the approaching direction. The numbers, 0, 1, 2 and 3 shown in the Figure 2.4 mean the approaching directions for the workpieces and also the directions for the approaching steps prior to the loading of workpieces on the pallet.

In case the initial workpiece is “1”, select Approach direction as arrow “0”.
Workpiece number order stacking workpieces is 1 → 2 → 3 → 4 → 5.

In case the initial workpiece is “3”, select Approach direction as arrow “1”.
Workpiece number order stacking workpieces is 3 → 2 → 1 → 5 → 4.

In case the initial workpiece is “5”, select Approach direction as arrow “2”.
Workpiece number order stacking workpieces is 5 → 4 → 3 → 2 → 1.

In case the initial workpiece is “4”, select Approach direction as arrow “3”.
Workpiece number order stacking workpieces is 4 → 5 → 1 → 2 → 3.

This is operation order according to incoming direction performing Palletize.
On even number layers, Palletize is processed by the order obeying the decision of incoming direction.

※ **Attention**

- Before doing teaching for Palletize Program, define stacking direction first. You should consider this point and then do teaching program.
- In workpiece teaching, if hand is chucking or forking, the interruption on other workpieces can be occurred. Therefore, you should do teaching as mark of Pattern Manual.

Reference

- When the approach direction of previous step is a quarter phase on the basis on workpiece position unloaded on pallet, set up approach direction as “0”.
  (See Figure 2.5 (a) REFERENCE1)

- When the approach direction of previous step is two-quarter phase on the basis on workpiece position unloaded on pallet, set up approach direction as “1”.
  (See Figure 2.5 (b) REFERENCE2)

- When the approach direction of previous step is three-quarter phase on the basis on workpiece position unloaded on pallet, set up approach direction as “2”.
  (See Figure 2.5 (c) REFERENCE3)

- When the approach direction of previous step is four-quarter phase on the basis on workpiece position unloaded on pallet, set up approach direction as “3”
  (See Figure 2.5 (d) REFERENCE4)

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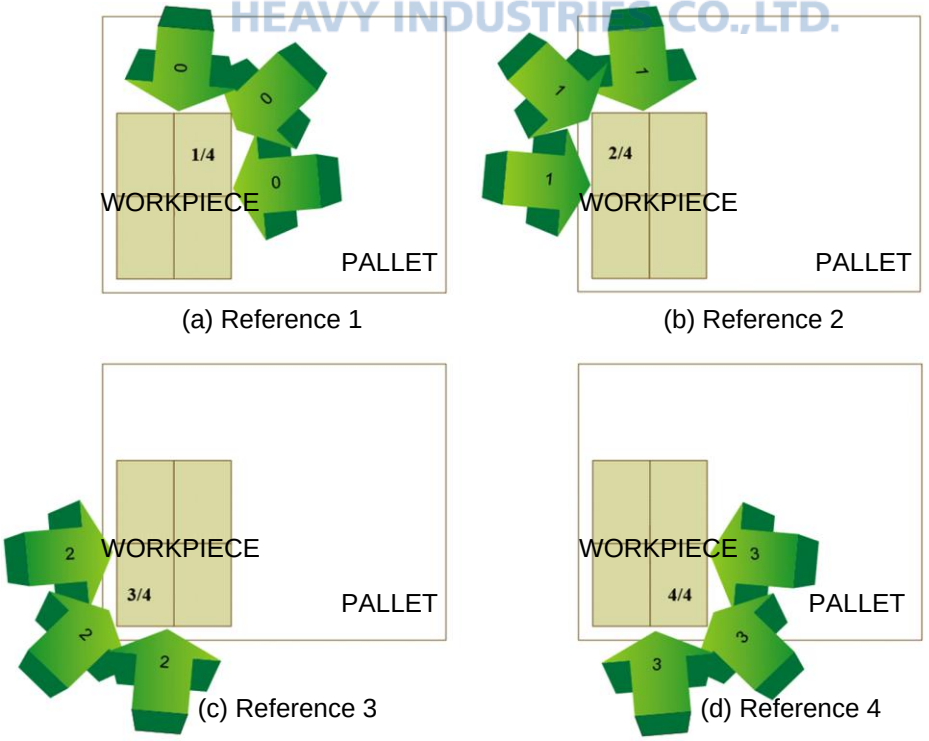

(a) Reference 1 (b) Reference 2

(c) Reference 3 (d) Reference 4

Figure 2.5 Reference

(9) Height deviation calibration (+: Higher, - : Lower)
Workpiece stacking height can be changed by mass or volume of workpiece. At this point, this is the setting item to offset irregular height variation of workpiece per layers.
You should know the difference of total height calculated by practical workpiece height and total height of stacking workpieces on the spot.

- ✓ Calculated stacking height (Hi) = practical workpiece height (H) × Total stacking level
- ✓ Field Measurement Stacking Height (Hr) = this is measured height after stacking workpieces.

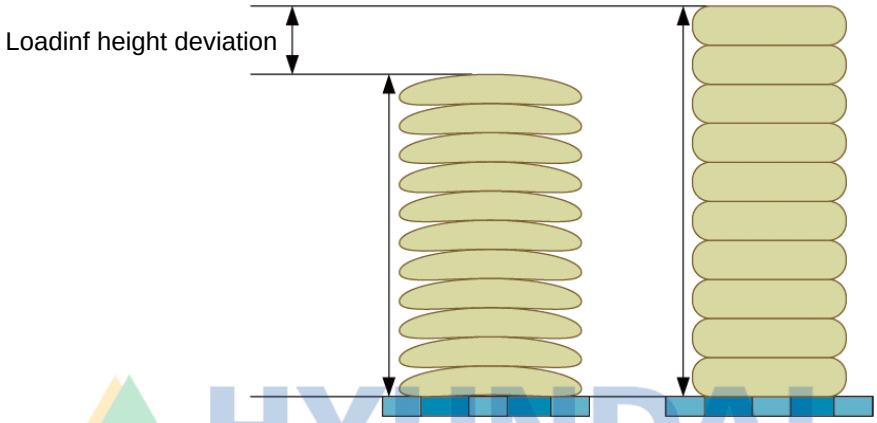

Figure 2.6 Deviation of Hr & Hi (Stacking Height)

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Height deviation by weight or volume = ((Current Operation Layer Unit – Deviation Offset begun) × Mean Variation)K

Figure 2.6 shows the difference (Stacking height deviation) between the height on the spot and the total height on calculation.

- **Height deviation by weight or volume = [1]**
  : To compensate layer height deviation, input beginning layer unit to reflect mean variation. Setting range is 1 to 100.

- **Sag or swell value (MdH) = [0.0]mm**
  : This is the mean value of the difference between calculated stacking height and field measurement stacking height.

$$Sag\ or\ swell\ value(MdH) = \frac{Calculated\ loading\ height(Hideat) - Field\ measuremen\ t\ height(Hreal)}{Total\ stacking\ level - Beginning\ applicatio\ n\ for\ change\ amount\ applicatio\ n}$$

  Setting rage is -255.0 ~ 255.0.

- **K (constant) = [1]**
  : This compensates the deviation by offsetting K constant according to layer height change.
  : Setting range is 1 ~ 3.

Reference

- If you do not consider layer height change, set up the layer which is impossible to stack as deviation application beginning layer.
- If layer height change is changed dramatically on certain position, set up 2 or 3. And if layer height change is changed as linearly, set up 1 and then use it.

※ Attention

- As layer height is longer, the position to unload workpieces has bigger error than the height of initial workpiece. Therefore, it can be a problem to stack workpieces safely.

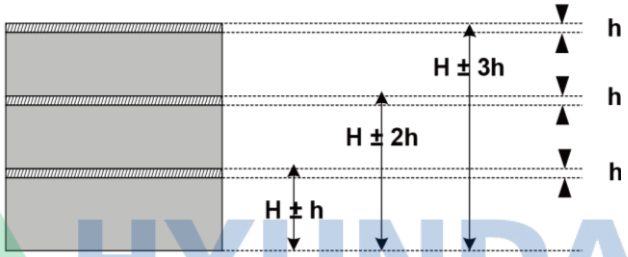

Figure 2.7 Layer Height Change by workpiece mass

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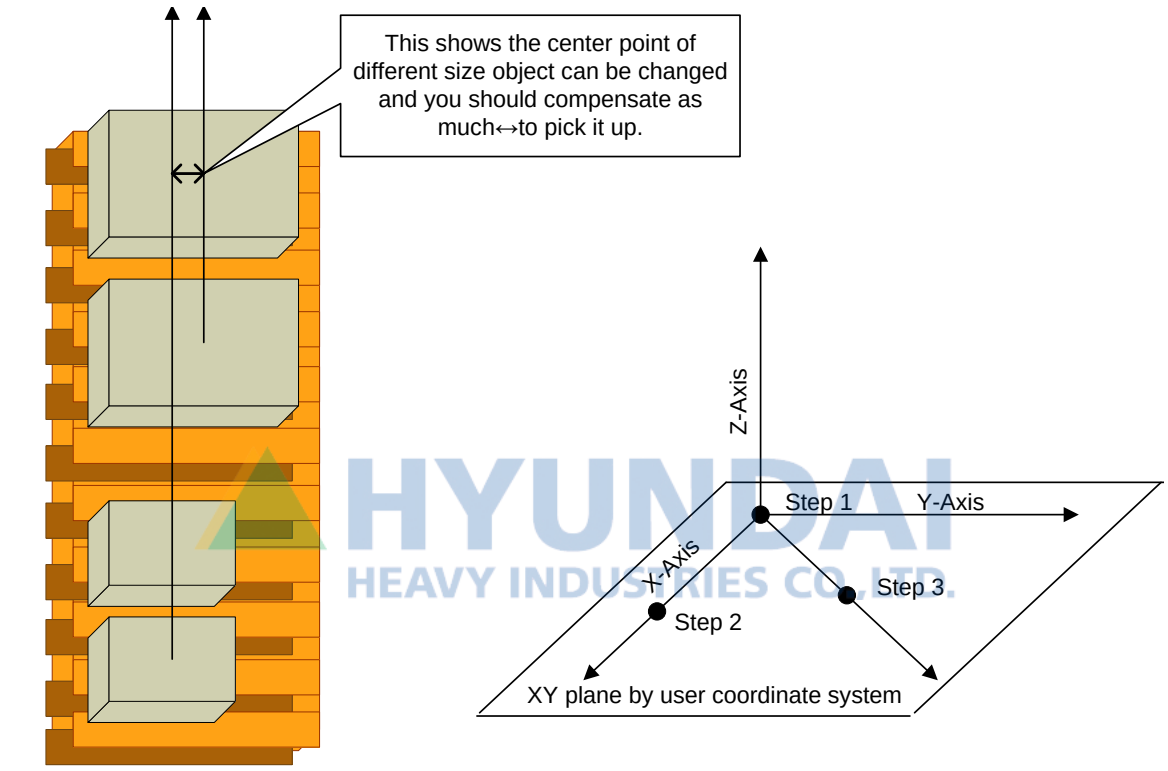
- ✓ H : Workpiece height
- ✓ h : Variation by mass or volume of workpiece

- Height deviation by weight or volume is the value to compensate stacking height deviation changed by stacking workpieces safely. Therefore, users should make optimized environment to stack it safely by setting up appropriate value.

(10) Hand =<Fork, Vacuum>
: For setting up this item, there are two cases.

- ✓ In case of changing position picking up workpiece according to kinds of handling tool.
- ✓ In case of changing position picking up workpiece according to workpiece size change.

You should keep up with position change that the robot picks up workpieces.



(a) Position(PK) change picking up workpiece

(b) Teaching method for user coordinate

Figure 2.8 Layer Height Change by Workpiece Mass

Check below methods for position change picking up workpieces.

- ✓ Select “Hand” as “Vacuum”.
- ✓ Do teaching for “User coordinate”.
- ✓ Set up teaching “User coordinate.”

※ Attention

- In case “Hand” is “Vacuum”, “user coordinate” is applied to picking step (PK).

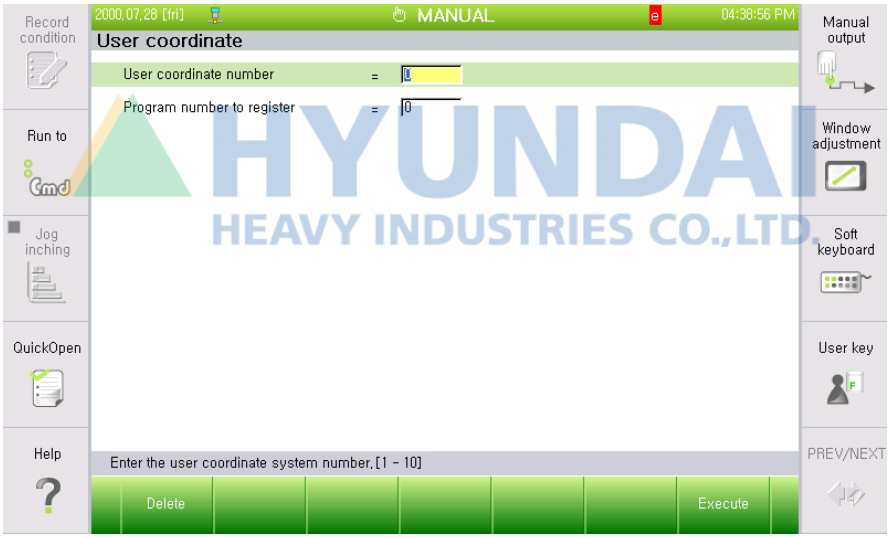
(11) User coordinate = [0]

User coordinate system is used only in case “Hand” is set up as “Vacuum” and the step “user coordinate” is applied is used only for “PK” step. (PK means the activity-picking up workpieces (picking)) Setting range is 1 to 10.

Register user coordinate system (See Standard step teaching method of three units for user coordinate system definition & Figure 2.8)

- ✓ Step 1: Define the zero point of user coordinate system.
- ✓ Step 2: Define the step defining X axis of user coordinate system.
- ✓ Step 3: Decide the directions of Y axis and Z axis as the step defining user coordinate system XY plane.

Select 『[F2]: System』 → 『2: Controller parameter』 → 『7: Coordinate registration』 → 『1: User Coordinate』 of manual mode. Input coordinate number to register and the number of program that teaching is done for three points to create corresponding user coordinate data and press 『[F7]: Execute』 key and then the registration of coordinate system is performed.



※ Attention

- When creating coordinate system, the teaching needs to be carried out based on the right hands.

Reference

- In user coordinate system, you can register up to total 10 units.
- CAUTION when recording standard point for coordinate definition
  - ✓ Standard three points should not be existed on the same straight line.
  - ✓ The distance of standard three points should not be closed too much.
  - ✓ Steps after Step No. 4 should not have any effect on registering coordinate system.

(12) Workpiece Information

Set up Standard Workpiece Size. The reason why decide the size of standard workpiece is the same as below,

To input it to calculate the position picking the practical workpiece compared to workpieces of various sizes and standard workpieces and stacking position.

To prevent deformation of pattern type according to the size of workpiece.
You should input accurate value by measuring the size of standard workpiece.

- Width(W>L , Always) = [0.1]mm
  Set up the width of workpiece size. For our Palletize Function, you should always set up the width (W) which is longer than length.

- Length = [0.1]mm
  Set up the length of workpiece size.

- Height = [0.1]mm
  Set up the height of workpiece size.
  Setting range is 0.1 ~ 3000.0

※ Attention

- Standard workpiece size is the standard of practical workpiece size of Palletize Shift (PAL, M96). And if you don't input it, position shift value to make pattern is not occurred. Therefore, you should input it.

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(13) Pallet Information

- Inclination of pallets per each axis (Θx,Θy,Θz)
  When stacking workpieces, consider the tilt of pallet and offset the tilt amount. Offset amount is reflected by being added or subtracted on shift amount. Measure the dip of pallet and input measured value.

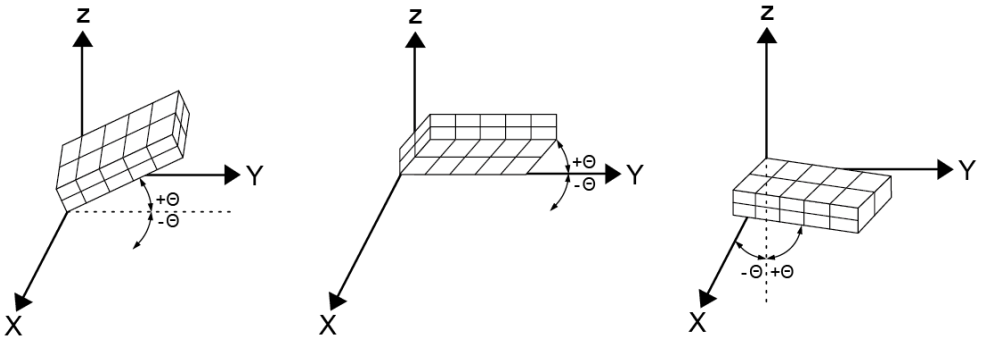

Figure 2.9 Patter Shift Change by Pallet slope Reflection about X, Y, Z axis

- How to measure Pallet slope
  On field condition, the tilt of conveyor and the ground are not even. Because of that, it is hard to measure tilting dip of pallet and even if measured, the result is not reliable. Therefore, this has the function to calculate the pallet slope automatically. Through this function, you can find the tilt of pallet easily.

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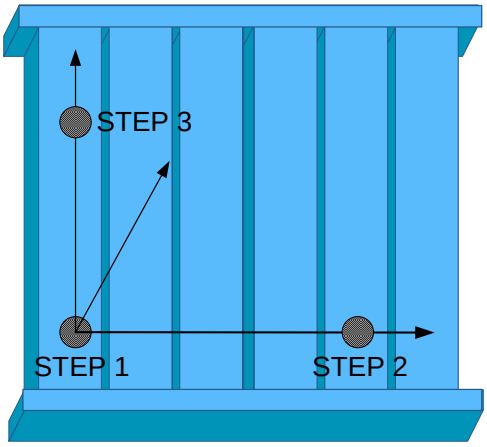
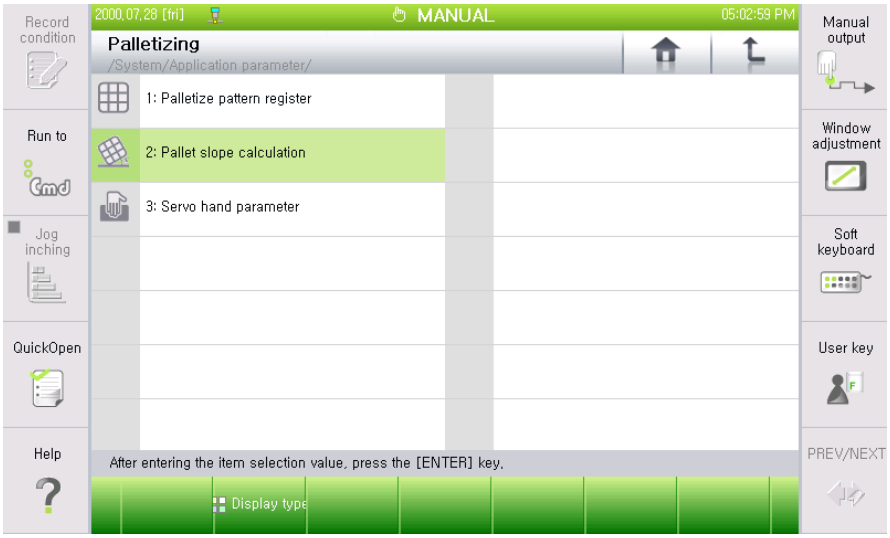


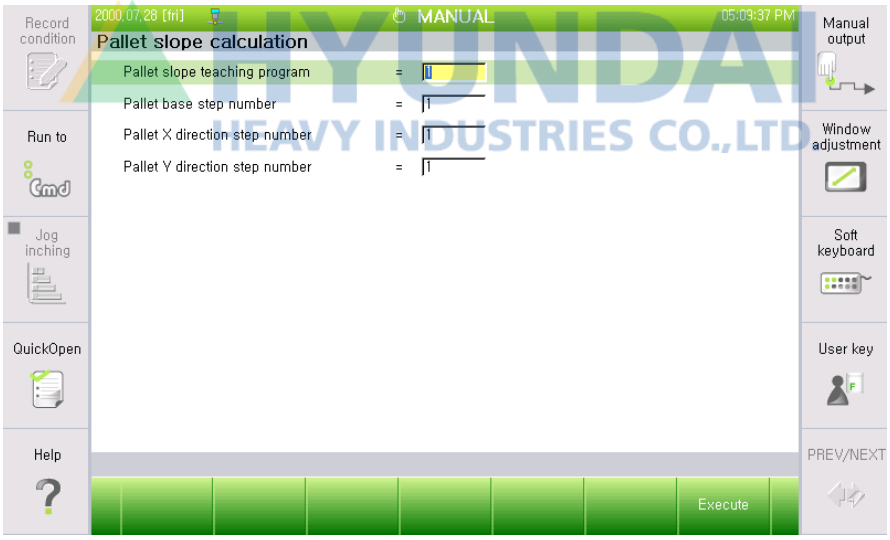
Figure 2.10 Slope Calculation Program Teaching Step

- ✓ Step 1: Register the position step to load pallet and initial workpiece.
- ✓ Step 2: Register the step to X axis direction (Robot Coordinate System Standard) of pallet.
- ✓ Step 3: Register the step as Y axis direction (Robot Coordinate System Standard).

① Select 『[F2]: System』 → 『4: Application Parameter』 → 『3: Palletizing』



② Select 『2: Pallet slope calculation』

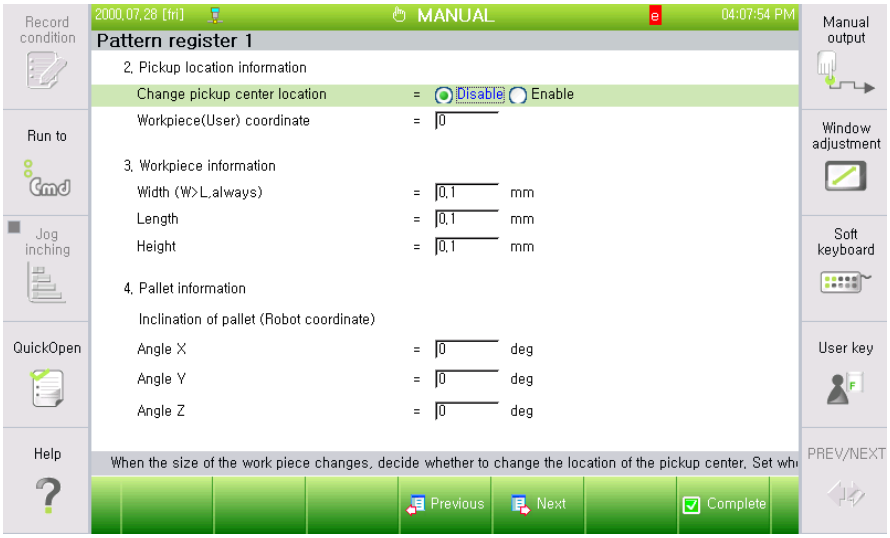


③ Item Input
- Pallet slope teaching program: For slope calculation, input written program number.
- Palletize base step number: Input “1”.
- Pallet X direction step number: Input “2”.
- Pallet Y direction step number: Input “3”.

④ After completing item input, press [Execute] key.

⑤ Mark marked X deg, Y deg, Z deg.

⑥ Input each axis dip marked to 『Palletize Pattern Register』 and 『Pallet slope』 in order.



- Angle X = [0.00] degree
  Input the tilt value on the center of robot coordinate X axis.
- Angle Y = [0.00] degree
  Input the tilt value on the center of robot coordinate Y axis.
- Angle Z = [0.00] degree
  Input the tilt value on the center of robot coordinate Z axis.
  Setting range is -180.00° ~ 180.00°

※ Attention

- Only when recording the step reached on “Pallet surface”, you can find accurate dip. And if you record the step while handling tool is mounted, record it by moving the tool of robot with minimum speed.
  Next move the program recorded as above to edit mode.
- When creating coordinate system, do teaching based on the left hand.

Reference

- The measuring result by pallet slope calculation appears once. Because of that, you should mark the measuring value. However, it appears when you input it to『Pallet slope calculation』
- The range of value measuring pallet slope is -180°~ 180° also the value input range is -180° ~ 180°. Therefore, check the measuring value is always measured based on the right hand.

(14) Inserting Tier-sheet

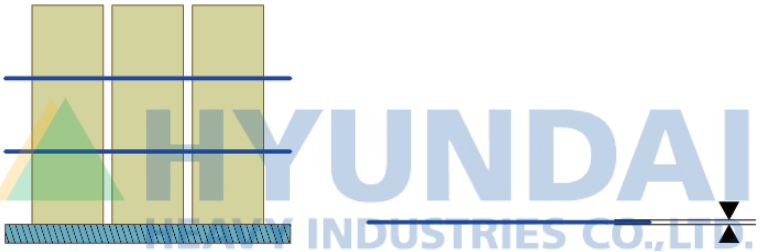
In case of stacking workpieces of several layers, insert tier-sheet between layers. On behalf of inserting tier-sheet,

- ✓ To protect workpieces between workpieces.
- ✓ To prevent collapse of workpieces of which heights are not even.
- ✓ To prevent moisture in workpieces.

- Tier sheet insert = every [0] level
  Set up the standard inserting tier-sheets. Decide the interval to insert tier-sheets. Setting range is 1 ~ 100.

- The last tier sheet insert = <No, Yes>
  Decide to insert an tier-sheet on the last tier-sheets.

- Thickness of tier sheet = [0.1]mm
  Input the tier-sheet thickness. When operating Palletize, insert an tier-sheet and then calculate the height of next layer automatically. Setting range is 0.1 ~ 500.0



(a) Inserting Tier-sheet (b) Tier-sheet Thickness

Figure 2.11 Inserting Tier-sheet / Tier-sheet Thickness

Figure 2.11 (a) shows inserting Tier-sheet per each layer of stacking pattern, Figure 2.11 (b) shows the thickness of Tier-sheet.

Reference

- When operating Palletize, Inserting Tier-sheet cannot be done from the upside pallet first. When operating Depalletize, it also cannot be done from the top.

- **After inputting each item, inputted value is saved by pressing 「[F7]: Complete」 key.**

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3 Teaching

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Before beginning Teaching, you should check or set up below items.

- Check whether Palletize is set at Usage Setting. If not, set it up.
- Check User key Setting is done properly.
- Check written user coordinate program is registered.
- Check written pallet slope calculation program.
- Check Palletize pattern register setting value is inputted accurately.
- If you record step, check step condition is set up by user's purpose.

3.1. Motion Pattern

Motion Pattern appears as below. Please refer to it.

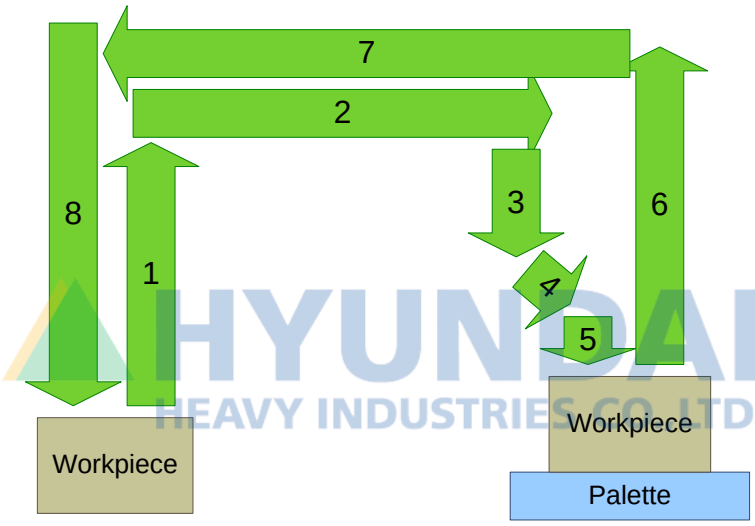

Figure 3.1 Palletize Motion Pattern Path

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3.1.1. Motion Path & Step Condition

Table 3-1 Motion Path & Step Condition

Path	Path Meaning	Beginning Step Condition			Target Step Condition		
		Interpolator	Accuracy	Function	Interpolator	Accuracy	Function
1	This is the path to pick up an workpiece.	on	0	PK	on	3	PU
2	This is the path to approach the position to unload an workpiece.	on	3	PU	off	3	PS
3	This is the path to approach the approach position to unload an workpiece.	off	3	PS	on	3	PS
4	This is the approach path to unload an workpiece safely.	on	3	PS	on	3	PS
5	Unload an workpiece on pallet.	on	3	PS	on	0	PS
6	This is the path to avoid interruption after unloading an workpiece.	on	0	PS	on	3	PS
7	This is the path to rotate S axis to the position to pick up an workpiece.	on	3	PS	off	3	PU
8	This is the path to move the position to pick up an workpiece.	off	3	PU	on	0	PK

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3.1.2. Step Teaching

To implement motion pattern as above, the program shows.

PAL P=1,PR=1,W=100.0,L=100.0,H=100.0
- To begin Palletize Function, input Basic Parameter.

PALPU P=1,SL=1,SH=100.0
- Input Picking-Up (PU) Ascent Shift Amount.

S1 MOVE L,S=100%,A=0,H=0,PK
- This is the step picking an workpiece (Picking, PK).

'Workpiece Chucking
- This is picking up an workpiece.

S2 MOVE L,S=100%,A=3,H=0,PU
- This is the step picking up an workpiece.
  Picking up (PU) compared to layer height to load.

S3 MOVE P,S=100%,A=3,H=0,PS
- This is the step (PS) rotating S axis to pallet position to unload an workpiece.

S4 MOVE P,S=100%,A=3,H=0,PS
- This is the approach step to unload an workpiece safely.

S5 MOVE P,S=100%,A=0,H=0,PS
- This is the position of half height of workpiece from the position to unload the workpiece. This is also the approach step.

S6 MOVE L,S=100%,A=3,H=0,PS
- Unload an workpiece on pallet.

'Workpiece Unchucking
- This is unloading an workpiece.

S7 MOVE L,S=100%,A=3,H=0,PS
- This is the ascent step avoiding the interruption of other workpieces after unloading an workpiece.

TIERST R=1,P=1,PR=1,TP=2
- If there is an tier-sheet, apply Tier-sheet Insertion Program Call Function.

S2 MOVE P,S=100%,A=3,H=0,PU
- This is the waiting step to pick up an workpiece, maintain the layer height and rotate S axis.

PALEND P=1,ES=0
- Terminate Palletize Function.

END
- Close program.

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3.1.3. Tier-sheet Program Writing

TIERST R=1,P=1,PR=1,TP=2

When inserting an tier-sheet, add this part to above teaching program. If there is an tier-sheet insertion, call the tier-sheet insertion program.

S1 MOVE P,S=100%,A=0,H=0 ▶ Move to the tier-sheet approach the position.

S2 MOVE L,S=100%,A=0,H=0 ▶ Pick up the tier-sheet.
DELAY 0.5 (Pick up the tier-sheet.)

SONL ST=1,CRD=0,R=1,S3 ▶ Lift up picking up the tier-sheet.
S3 MOVE L,S=100%,A=0,H=0

S4 MOVE P,S=100%,A=0,H=0 ▶ Move to the position of the layer to unload the tier-sheet.

S5 MOVE L,S=100%,A=0,H=0 ▶ Unload the tier-sheet.
DELAY 0.5 (Unload the tier-sheet)

S6 MOVE L,S=100%,A=0,H=0 ▶ Avoid the position unloading the interleaving paper.

SONL ST=0,CRD=0,R=1,S3 ▶ Close tier-sheet insertion program and return to main program.
END

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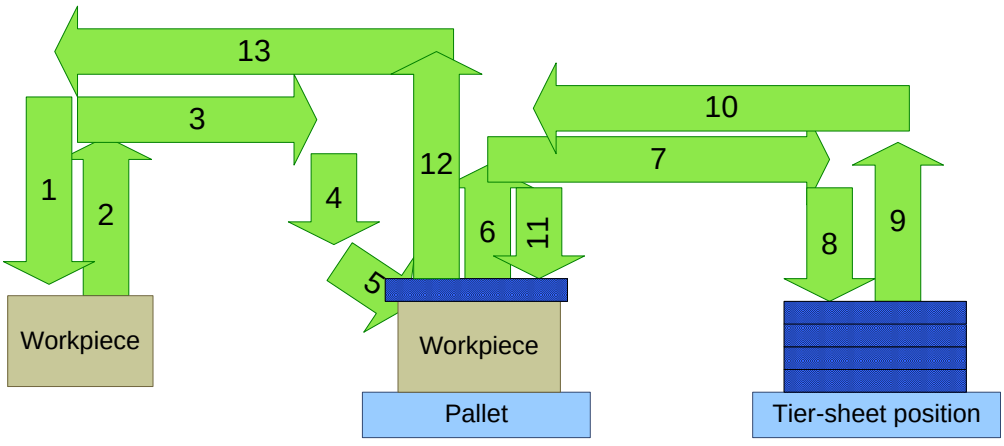


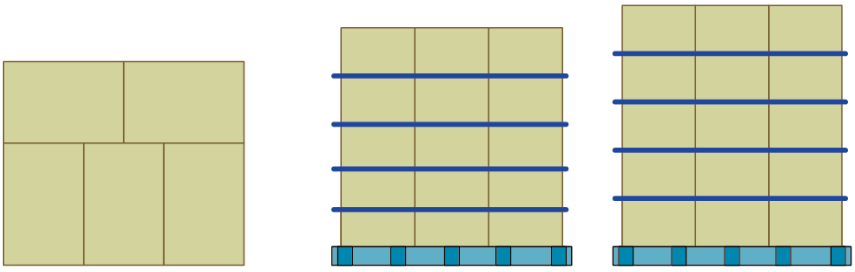
Figure 3.2 Palletize Motion Pattern Path when inserting the tier-sheet

Reference

- Above Teaching Program shows the example of Operation Program Configuration when doing 『Palletize Operation』 containing 『Tier-sheet』
- For the shift amount of tier-sheet insertion program, see the value inputted on Palletize Pattern Register.

3.1.4. Example of micro offset program writing (Palletize Function + Shift Function)

Users can control optionally the position data value created while using Palletize Function and then they can use it performing the existing shift function simultaneously to reflect the value of dX, dY, dZ.



(a) Pattern Figure (b) In case the heights per layers are not even

Figure 3.3 Pattern Figure & In case the heights per layers are not even

For example, when you loaded 5 layers as shown in Fig. 3.3 and would like to apply different amounts to shift for each layer, you must prepare a program.

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```
V1%=_PALCNT1% 6
IF (V1%=1) THEN
R1=0.0,0.0,-10.0,0.00,0.00,0.00
ELSEIF (V1%=2) THEN
R1=0.0,0.0,-11.0,0.00,0.00,0.00
ELSEIF (V1%=3) THEN
R1=0.0,0.0,-12.0,0.00,0.00,0.00
ELSEIF (V1%=4) THEN
R1=0.0,0.0,-13.0,0.00,0.00,0.00
ELSEIF (V1%=5) THEN
R1=0.0,0.0,-14.0,0.00,0.00,0.00
```

▶ Function jump by Palletize Count

▶ Shift Amount Substitution (For each stage)

```
ENDIF
```

▶ Terminate Function Jump

```
    PAL P=1,PR=1,W=100.0,L=100.0,H=100.0
    PALPU P=1,SL=1,SH=100.0
S1  MOVE P,S=100%,A=0,T=0,PK
    workpiece Picking
S2  MOVE P,S=100%,A=0,T=0,PU
    SONL ST=1,CRD=0,R=1,S3
```

▶ Begin Online Shift Function

```
S3  MOVE P,S=100%,A=0,T=0,PS
S4  MOVE P,S=100%,A=0,T=0,PS
S5  MOVE P,S=100%,A=0,T=0,PS
S6  MOVE P,S=100%,A=0,T=0,PS
    F001: workpiece Place down
```

```
S7  MOVE P,S=100%,A=0,T=0,PS
    SONL ST=1,CRD=0,R=1,S3
```

▶ Terminate Online Shift Function

```
TIERST R=1,P=1,PR=1,TP=2
```

▶ Call Tier-sheet Program and Online Shift register which is the same as M68.

```
S8 MOVE P,S=100%,A=0,T=0,PU
   PALEND P=1,ES=0
   END
```

▶ Terminate Palletize

※ Attention

- At the teaching program, _PALCNT (Palletize Count) should precede PAL (Palletize Shift) always.
- The same shift register number as the one used for the identical work should be used.
- Prior to TIERST (In-between paper insertion program), SONL (Online Shift Function) needs to be ended.

Reference

- PALCNT manages the palletizing counter for each work pattern. The use of the flow control door allows various applications.
- As examples of various applications, the workpieces can be adjusted minutely, and the pallets can be inserted, and the workpieces can be stacked up in a pyramid shape or in a echelon format.

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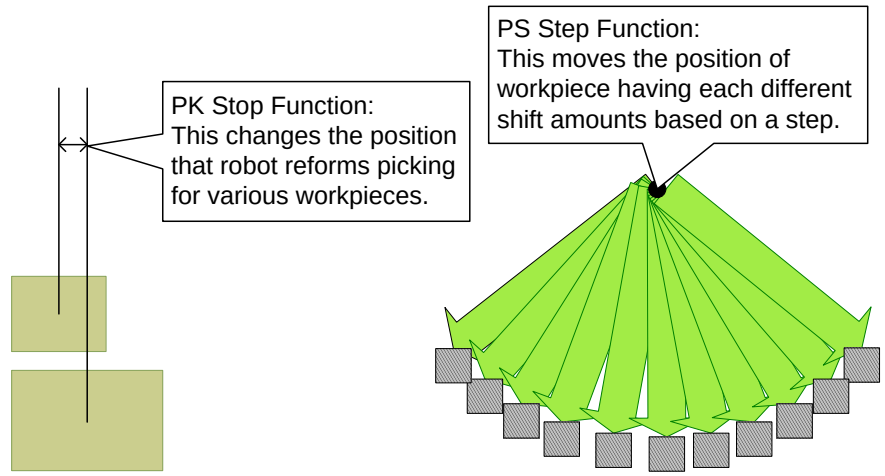
3.1.5. PK (Picking), PS (Palletize Shift), PU (Picking-Up) Function



(a) Picking (PK) Step Function (b) Palletize Shift (PS) Step Function

Figure 3.4 Function of Picking (PK) Step & Palletize Shift (PS) Step

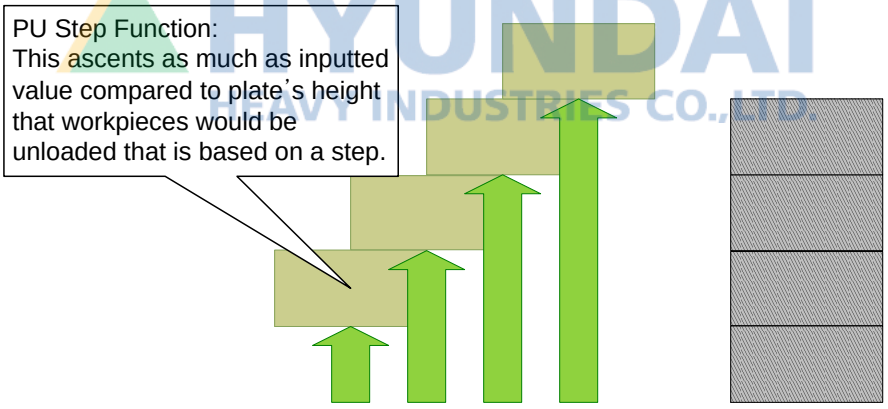


Figure 3.5 Function of Picking-Up (PU) Step

Reference

- PK, PU, PS assign the function to perform Palletizing and proper step condition should be used by user's decision. There are two ways to set up PK, PU, PS.

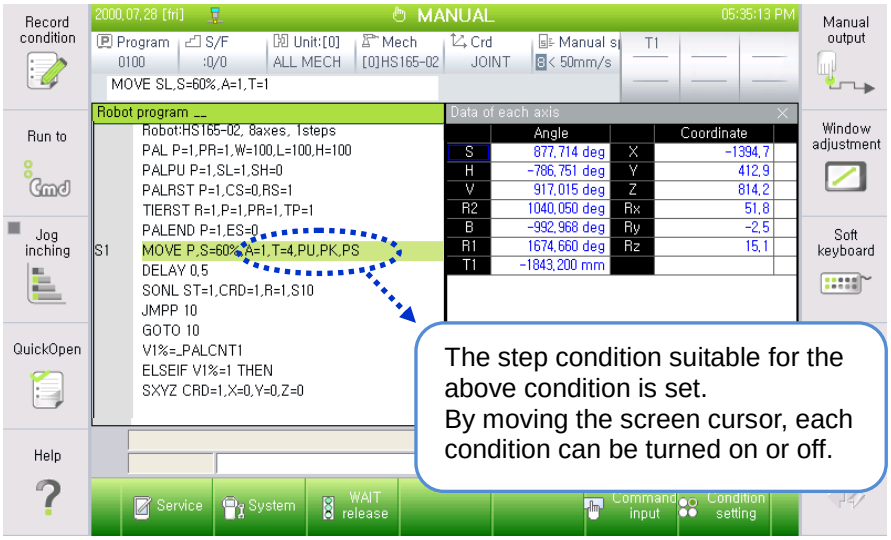
  ① Setting Method using user key (f1, f2, f3, f4) (See 『Hi5 Controller Operation Manual』)
  ② After finishing Step Teaching, you can set it up as command adjustment.

※ Attention

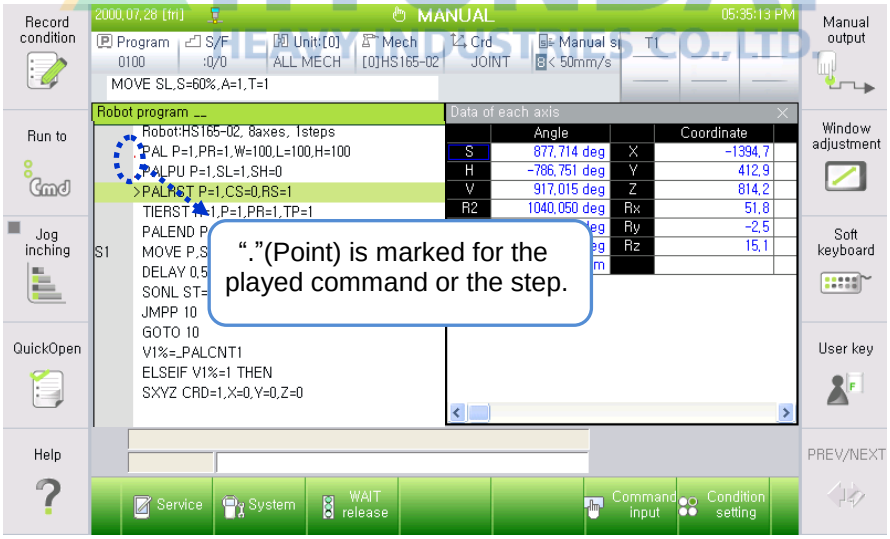
- While teaching a robot, not only the first teaching step, but it is also fully considered that step position to be shifted can be existed in motion range of robot. If not, error messages appears as below, 『Arm angle is too small(big)』, 『It exceeds soft limit.』. In this case, you can solve it through adjusting teaching step.

3.1.6. Screen Configuration when doing step teaching & playback

(1) These screens are the part of teaching program.



(2) This is the screen when doing playback of Palletize Function Program.



※ CAUTION of Error Occurrence

- When the step condition and the program are to be edited at the manual mode, the role of each step needs to be memorized. This can set the wrong conditions for a step and make the robot work along a path not desired.

3.2. Command Language

3.2.1. Tier Sheet Program Call (TIERST) Input

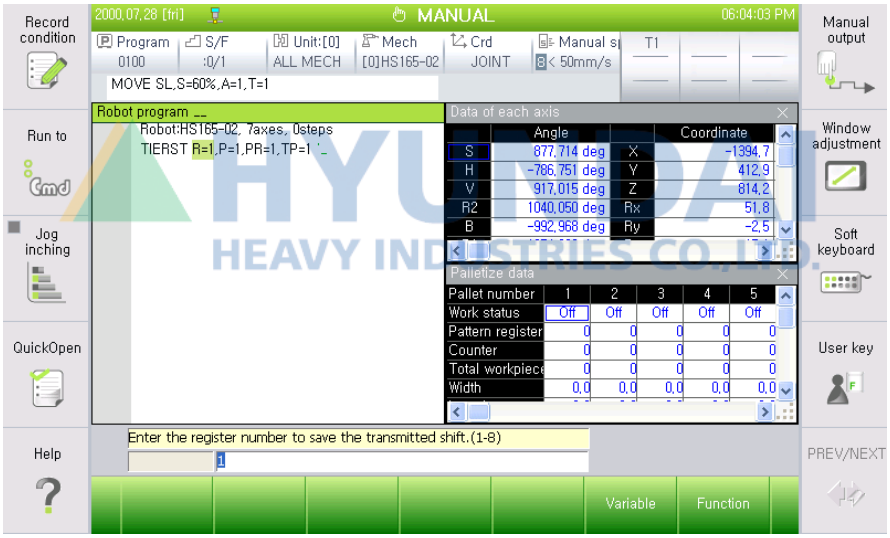
(1) Input TIERST command.

(2) Input Online Shift Register.
[Input Register No. (1 - 8)]

(3) Input Palletize Pallet No.
[Input Palletize Pallet No. (1 - 16)]

(4) Input Palletize Pattern Register No.
[Input Palletize Pattern Register (1 - 16)]

(5) For interleaving insertion, input Program No. to call.
[Input Interleaving Insertion Program (0 - 999)]



■ Palletize Pallet No. is marked as P#.

3.2.2. Palletize Picking-Up Shift (PALPU) Input

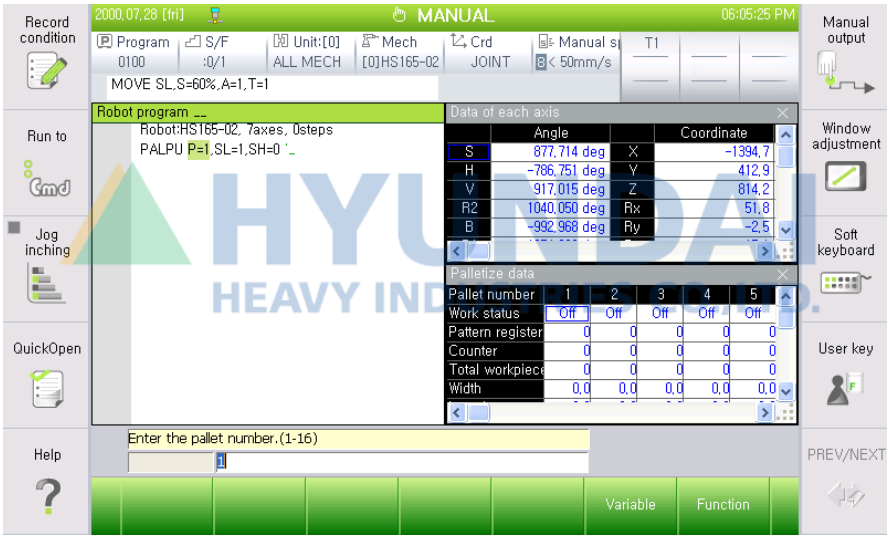
(1) Input PALPU command.

(2) Input Palletize Pallet No.
[Input Palletize No. (1 - 16)]

(3) Input Beginning Layer Unit.
[Input Beginning Layer Unit. (1 - 100)]

(4) Input Shift Amount.
[Input Picking Ascent Shift Amount (-2000 - 2000)]

When it comes to the record of the Palletize Picking-Up Shift, it will be shown as below when, after the step is set at the manual mode, PALPU is entered and each parameter is set according to the announcement.



■ Palletize Pallet No. is marked as P#.

3.2.3. Palletize Shift Input (PAL)

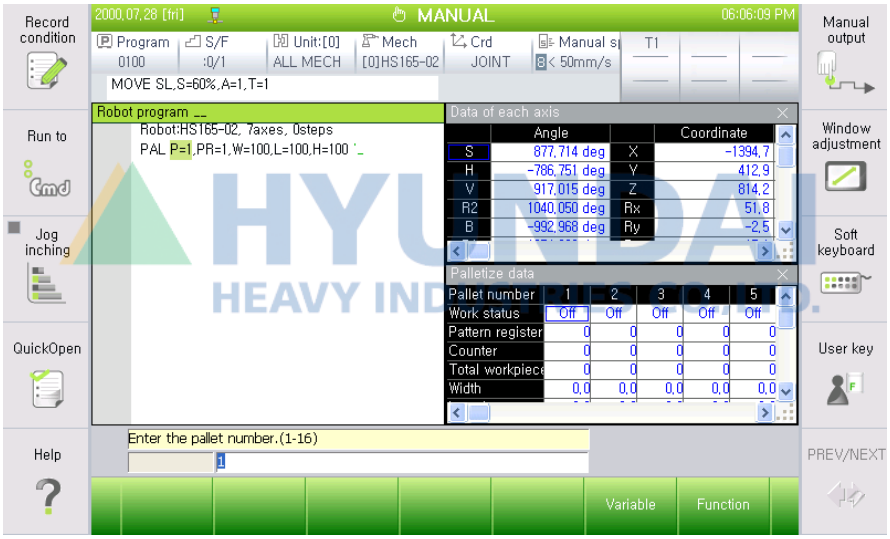
(1) Input Command Language (PAL).

(2) Input Palletize Pallet No.
[Input Palletize Pallet No. (1 - 16)]

(3) Input Palletize Pattern Register.
[Input Palletize Pattern Register (1 - 16)]

(4) Input workpiece's size.
[Input workpiece's size W, L, H. (0.1 - 3000)]

When it comes to the record of the Palletize Shift function, it will be shown as below when, after the step is set at the manual mode, PAL is entered and each parameter is set according to the announcement.



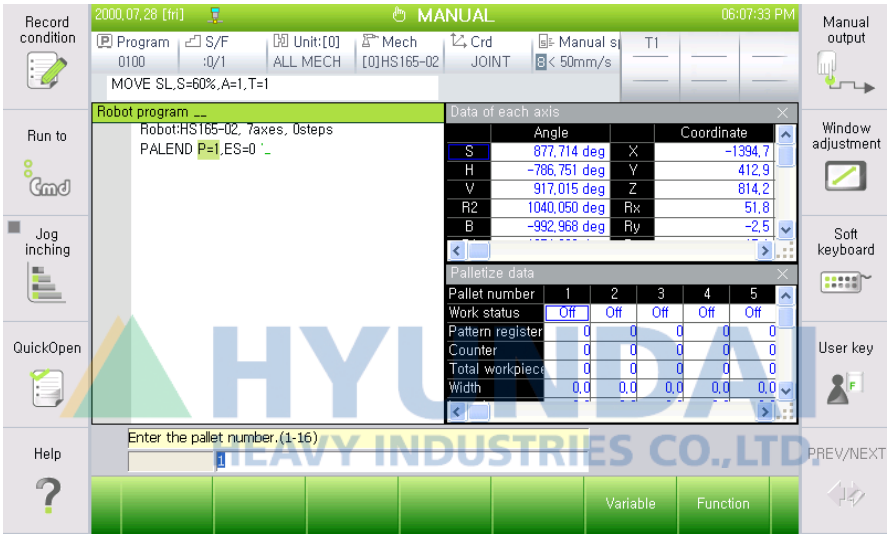
- Pallet No. is marked as P#, and Register No. is marked as D#.

3.2.4. Palletize End Input (PALEND)

(1) Input Pallet No.
[Input Palletize Pallet No (1 - 16)]

(2) Input Closing Output Signal. (O Signal)
[Input Closing Signal (0 - 318)]

When it comes to the record of the Palletize End function, it will be shown as below when, after the step is set at the manual mode, PALEND is entered and each parameter is set according to the announcement.



■ Pallet No. is marked as P#.

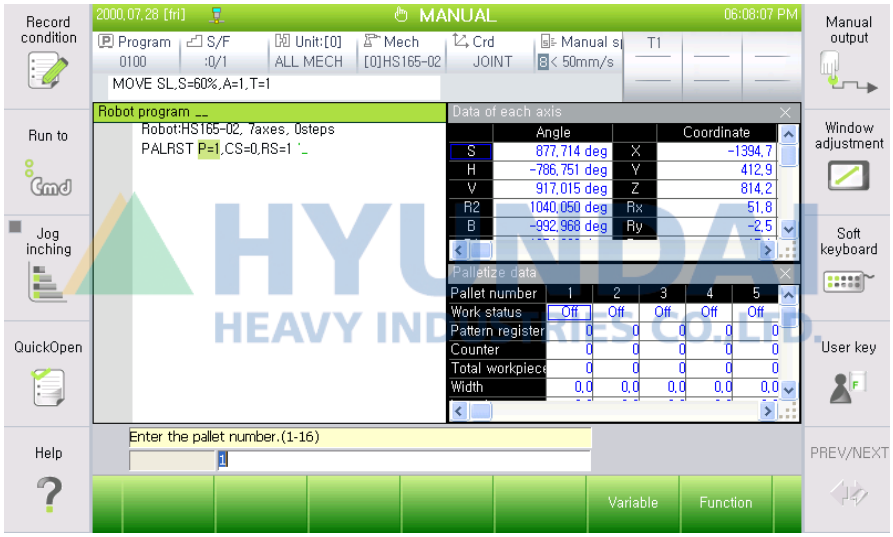
3.2.5. Palletize Reset Input (PALRST)

(1) Input Pallet No. [Input Palletize Pallet No. (1 - 16)]

(2) When the Forced Reset needs to be carried out, the DI condition signal to be received from the outside needs to be entered.
[Input Condition Signal (0 - 240)]

(3) Input Closing Output Signal. [Input Response (Ack) Signal (1 - 318)]

Palletize Forced Reset is used for terminating Palletize Operation forcefully because the situation to halt loading is occurred in external. The process is I Signal Input → Output Response Signal → Pallet Exit. For the record of Palletize Forced Reset Function, set up the step in manual mode, input PALRST and then set up each parameter value according to guide message. And then the screen appears as below,



■ Pallet No. is marked as P#.

※ Attention

- You should accurate Pallet No.

4 Playback

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After the Palletize program is prepared, it is required to move forward 1 step at the teaching mode and check the travelling path of the robot.

4.1. Playback of PK Step

This is applied to the step picking up an workpiece.
When picking up an workpiece, perform shift as much as position change amount according to the workpiece size.

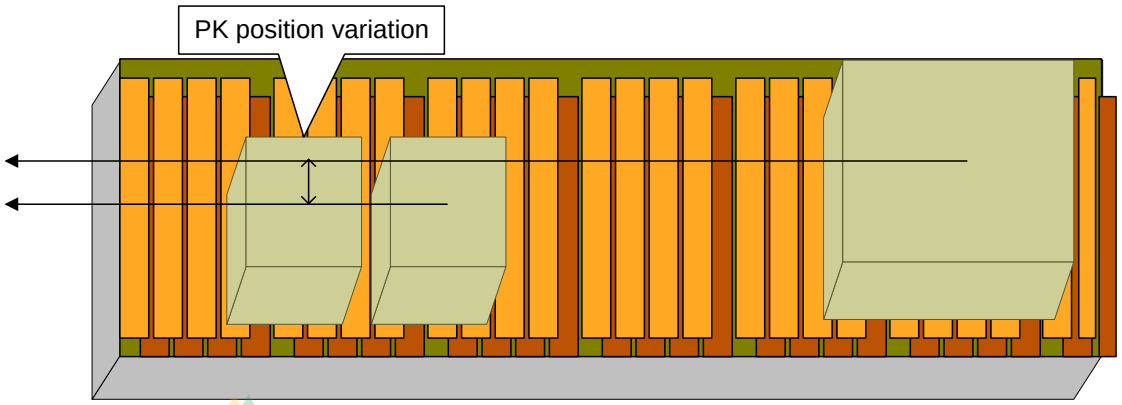

Figure 4.1 The role of PK in case different size workpieces come from C/V

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4.2. Playback of PS Step

After performing approach step, loading step and loading, this is applied to avoidance step.
In the step that PS is set up, perform shift for the step having each different shift amount according to pattern type.

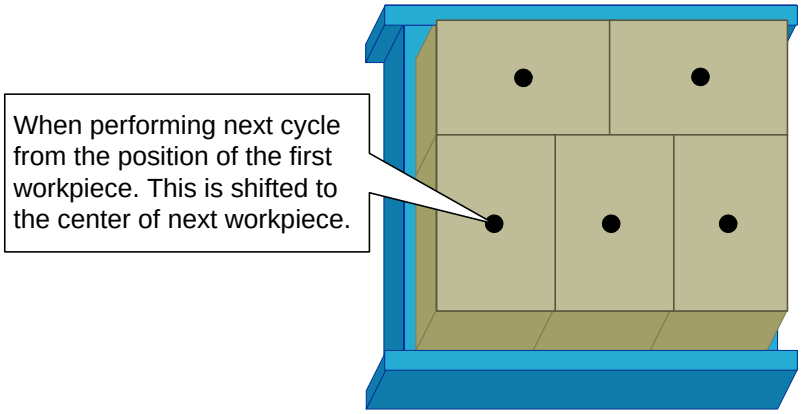

Figure 4.2 In the position that the first workpiece is unloaded, this is the rule of PS finding shift amount in the center of next workpiece.

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4.3. Playback of PU Step

This is applied to the step picking and lifting an workpiece. After picking up an workpiece, compare the height of avoidance step to the height of layer and then make it possible to control shift amount of avoidance step. When the step condition PU is used, the unnecessary travelling path of the robot can be minimized.

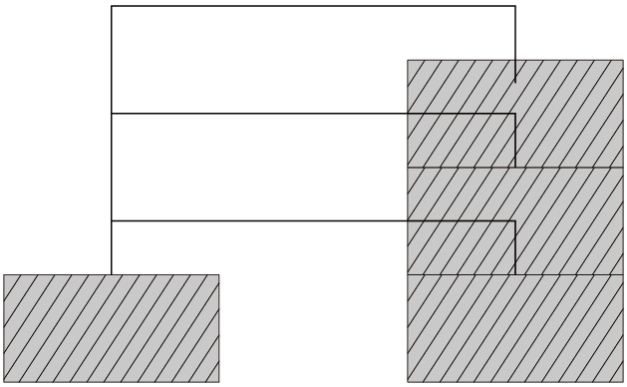

Figure 4.3 The rule of PU shifting the step picking and lifting an workpiece according to the layer height.

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Reference

- If there is Palletize Shift (PAL) command language only, step option of PU, PS, and PK is applied.

5 Service Menu

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5.1. Palletize Monitoring

This shows the information about Palletize on processing.

Items appear as below,

(1) Work State: View the state Palletize is on processing.

(2) Pattern Register: View Palletize Pattern Register No.

(3) Counter: View the current counter amount of Palletize.

(4) Total workpiece: View the total number of Palletize workpiece.

(5) Width: View current Run Box Size (W).

(6) Length: View current Run Box Size (L).

(7) Height: View current Run Box Size (H).

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5.1.1. How to operate

(1) Select 『[F1]: Service』 → 『1: Monitoring』.

(2) Select 『[F1]: Service』 → 『1: Monitoring』 → 『6: Palletize Data』.

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5.2. Palletize Register

5.2.1. Mark Item

Items are the same as below,

(1) Palletize Register
You can set up shift amount optionally for Palletize. This can be used to check the shift amount before performing an operation and check the coordinate value rather than using it on practical Palletize.

(2) Palletize preset
You can set up Palletize counter value optionally. Begin the operation from the counter of the value that setting is done.

(3) Palletize Reset
You can reset forcefully Palletize Register and counter value on processing. Terminate Palletize Operation of pallet on processing. In manual mode, you can reset Palletize using R code (R55).

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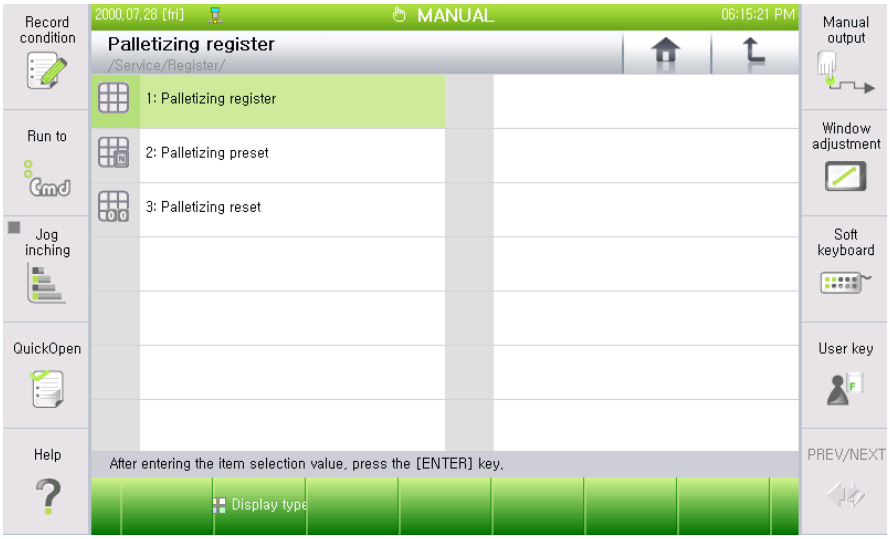
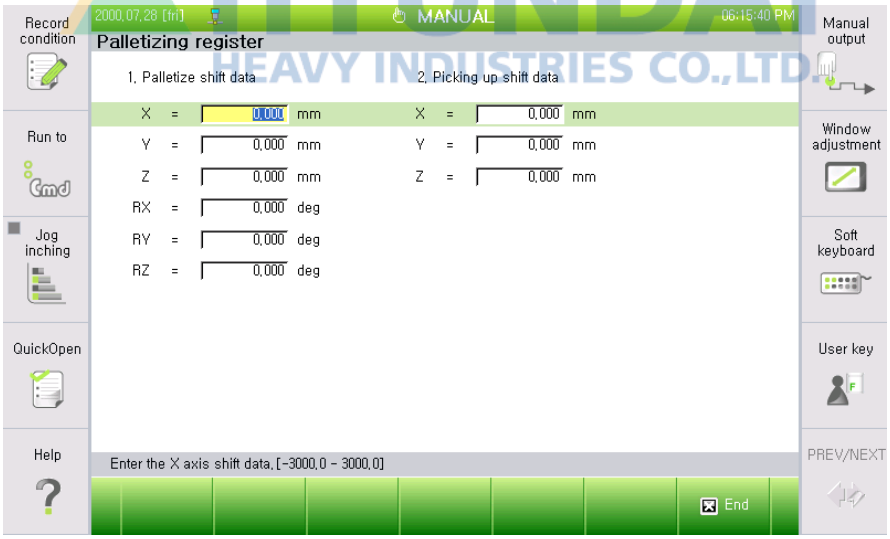
5.2.2. How to operate

(1) Select 『[F1]: Service』 → 『2: Register setting』 → 『4: Palletizing Register』.

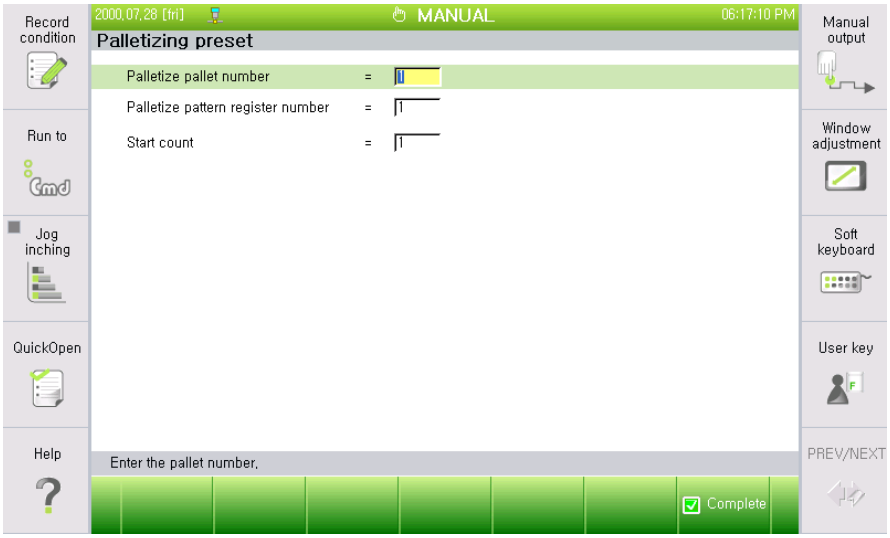


(2) Select 『1: Palletizing Register』.



- Palletize shift data: View or input the data value to shift.
- Picking up shift data: View shift amount performing Picking-Up.

(3) Select 『2: Palletizing preset』.



- Palletize pallet number: Input the number of pallet to designate in advance.
- Palletize pattern register number: Input Pattern Register No. on use.
- Start count: Input the number of beginning operations.

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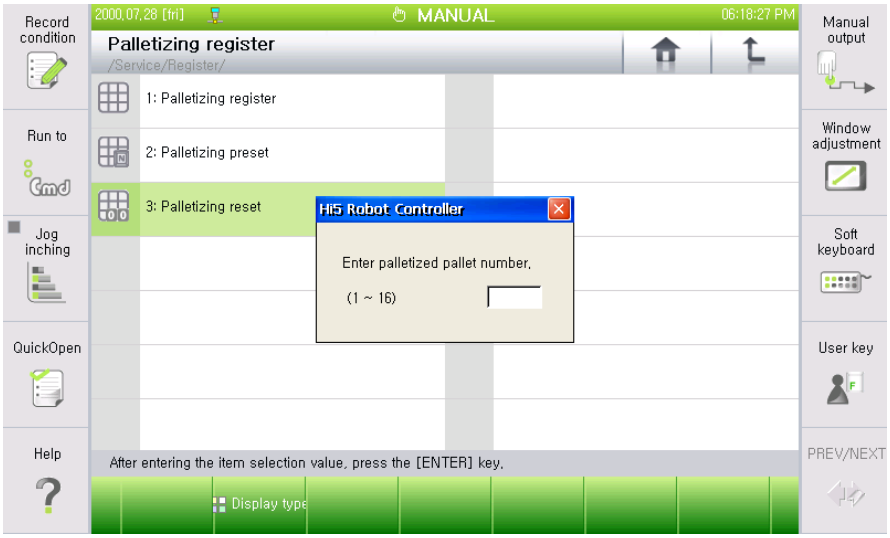
(4) Select 『3: Palletizing reset』.

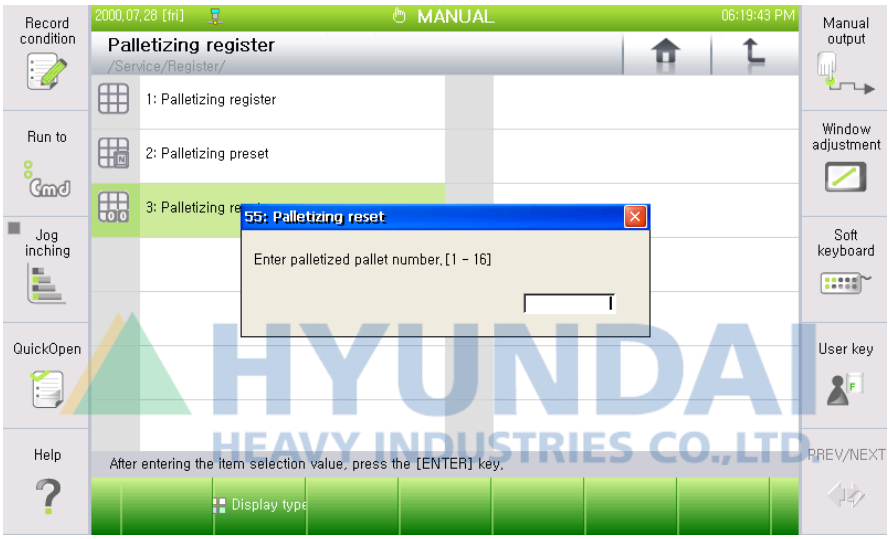


※ CAUTION of Error Occurrence

- In case of changing register value or inputting it newly, you should be careful of that because this is always related to the shift motion of robot. In addition, register value change is impossible on robot playback. However, free-set is possible to use except the pallet on processing.

Reference

- When inputting R55 in manual mode, Palletize Count Reset is possible.



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6

Creation & Management Palletize Pattern File

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To perform Palletize Function, you should manage Palletize Pattern Register which is written necessarily. And then when initializing the controller, you can backup or load for Palletize Pattern Register which is inputted in advance. The authorized name of this file is Palletize Pattern File and file name is ROBOT.PAL file.

6.1. Palletize Pattern File (ROBOT.PAL) Creation

(1) When, at the 『[F2]: System』 → 『5: Initialize』 → 『4: Usage Setting』, the palletizing option is set for the Usage Setting, the palletizing pattern file will be created.

(2) You can check the file creation by selecting 『[F1]: Service』 → 『5: File Manager』 → 『1: Show file names in memory』.

(3) Even after a change is made in Usage Setting, the previously prepared file exists still until it is deleted.

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6.2. Palletize Pattern File (ROBOT.PAL) Recreation

(1) If there is a file previously prepared and the Palletize option needs to be set for the usage, there will be a question 『ROBOT.PAL file existent. Do you want initialize it? [Y/N]』

(2) If you want to rewrite a file, input YES key, if you want to use the exiting file, input No key.

(3) When inputting yes key, new Palletize Pattern File (ROBOT.PAL) is recreated.

※ CAUTION of Error Occurrence

- When recreating a file, the existing written Palletize Pattern Register File (ROBOT.PAL) is deleted automatically. In this case, you cannot use Palletize Pattern Register which is used in the existing teaching program.

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7 Troubleshooting and Errors

Following errors may occur when palletizing functions are used.

Code	E1321 Pallet number is not the same.
Cause	When working on palletizing in the same pallet, all the palletizing relevant instructions should be input with the same pallet number between the two instructions including PAL and PALEND. This error occurs when these pallet numbers are not set to be different.
Action	1) Check the pallet number for palletizing instructions of TIERST, PALPU, PAL, PALEND, PALRST in the same palletizing work. 2) Input the same pallet numbers.

Code	E1322 Pattern register not used.
Cause	For palletizing work, information should be set in a palletizing pattern register. This error occurs when an unused pattern register is set out of 16 pattern registers in total.
Action	1) Check the set pattern register number 2) Check the items in use/out of use among palletizing pattern registers.

Code	E1324 Palletizing work environment setting error.
Cause	If this Palletize function is used without setting Palletize at System/Initialization/Usage Setting, there will be an error.
Action	Set Palletize at System/Initialization/Usage Setting

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Code	E1325 Palletized pickup function usage error.
Cause	This error occurs when PALPU (picking up shift) is not between PAL and PALEND in program. For the use of picking up shift of PALPU, shift generated from PAL is required, so PALPU must be located between PAL and PALEND in program.
Action	1) Position the PALPU between PAL and PALEND in program.

Code	E1148 Palletized function already executed.
Cause	Palletize starting instruction is given while palletizing function is already operating.
Action	Check the details of program.

Code	E1150 Cannot be used during palletize.
Cause	The Palletize Reset command is executed while the Palletize function is being performed
Action	End palletizing before the execution.

Code	E1166 Coordinate system setting based on palletize is inaccurate.
Cause	The standard coordinate system setting of palletizing function is incorrect.
Action	Check the palletizing function parameters in the program.

- **Can't use! Choose other Pattern No. [ANY]**
  When an inapplicable pattern has been selected, check out which pattern can be available.

- **Re-enter a pattern & sub pattern No. [ANY]**
  In case that an inapplicable pattern has been configured to use, the user should input a sub-pattern after inputting a pattern number by choosing a sub-pattern number and then a pattern number.

- **Can't use! Choose other Sub Pattern No. [ANY]**
  When an inapplicable sub-pattern has been selected, check out which sub-pattern can be available.

- **Cannot use! This environment cannot be set. [ANY]**
  Without setting the Palletize option for the Constant Setting mode and the Initialization at the Usage Setting,
  ① To configure the palletize pattern register.
  ② To configure the palletize register for service.
  ③ To configure the function of monitoring for service.

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- **In palletize mode, Use only! [ESC]**
  It is impossible to enter PALPU, PAL, PALEND, and PALRST without setting the Palletize option for the Constant Setting mode and the Initialization at the Usage Setting

- **Excess of selected counter to total[Any]**
  When the initial number is configured as “0” at the palletize preset setting, the user should exit this stage by inputting the [ESC] key.

- **Ref.)Only available for a vacuum tool!**
  Attempting to set up the user coordinate with the handling tool configured as “poking,” the user should first configure the handling tool as “vacuum.”

- **User coordinate of selected No. isn't exist**
  This message shows up when the user tries to select an unregistered user coordinate with the handling tool configured as “vacuum.”

- **Stationary gun need to set coordination.**
  This message shows up when the user pushes the setting key [F7] without selecting a user coordinate after configuring the handling tool as “vacuum.” The user should select a registered user coordinate or teach the user coordinate, if not teached.

- **Tier sheet insertion is wrong. [Any]**
  This message shows up when the criterion number of in-between papers exceeds a total number of stacks. The user should reconfigure the criterion number of in-between papers as lower than a total number of stacks.

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Following errors may occur when the “user coordinate is used”.

Code	E1010 Number of teaching step is insufficient
Cause	The number of steps in recording program for setting the User coordinate system or automatic setting for conveyor degree.
Action	- Automatic setting for conveyor degree : 2 of steps(straight line), 3 of steps(round shape) required - Setting for User coordinate system : 3 of steps required

Code	E1011 Recorded dots are too close
Cause	Step positions of recorded program for automatic setting for conveyor degree is too close each other so that conveyor degree cannot be obtained.
Action	For straight line conveyor, record 2 points at intervals of approximately 1m.

Code	E1012 Recorded dots exist on a straight line
Cause	Coordinate data cannot be acquired as the 3 steps are positioned on a liner line at the program prepared for setting the User coordinates.
Action	Refer to MANUAL, and position the 3 points in the same plane but in a straight line.

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Following messages may occur when 『Pallet slope calculation』.

- **Teaching points too close! [ESC]**
  This message shows up when teaching steps are too close to calculate pallet’s reclining angle. In this case, the teaching program should be modified.

- **Teaching program does not exist! [ESC]**
  This message shows up when the program number for the measurement of reclining angle is improperly selected or when the program’s steps are short of what’s required. In this case, check out whether the selected file does exist or the teaching is properly made.

- **Step in the program doesn't exist! [ESC]**
  This message shows up when the program’s steps selected for the measurement of reclining angle cannot be found. Check out the selected teaching program for possible errors.

- **Teaching points are the same line [ESC]]**
  This message shows up when three dots registered for the measurement of reclining angle are almost placed on the same straight line, so that the measurement cannot be achieved. Check out the teaching program for possible errors.

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8

Palletize Loading Pattern

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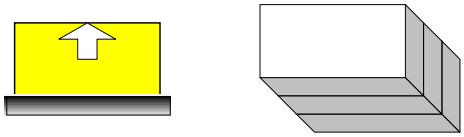
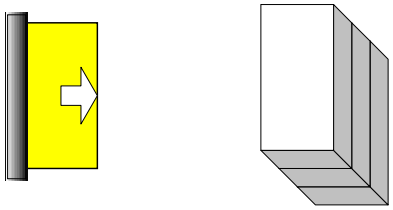
8. Palletize Loading Pattern

1

Pattern number 1



Pattern number 2



Pattern number 3

Pattern number 4

Pattern number 5

Pattern number 6

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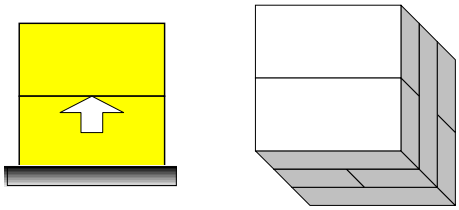
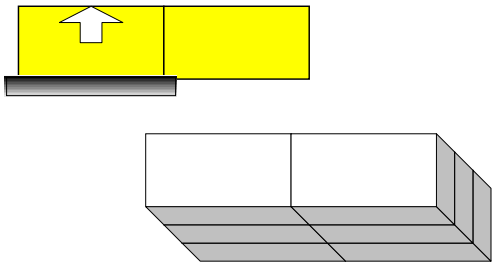
2

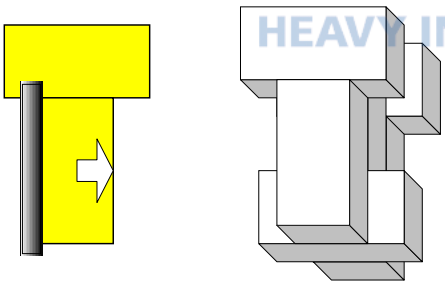
Pattern number 1



Pattern number 2



Pattern number 3



Pattern number 4

Pattern number 5

Pattern number 6

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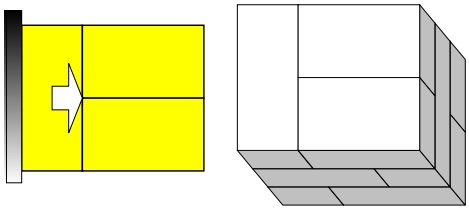
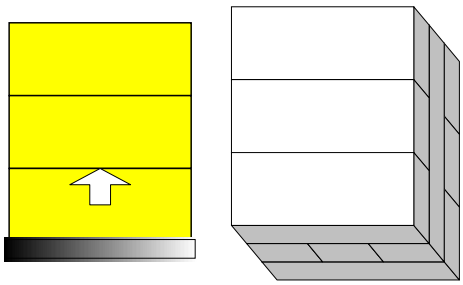
3

Pattern number 1



Pattern number 2



Pattern number 3

Pattern number 4

Pattern number 5

Pattern number 6

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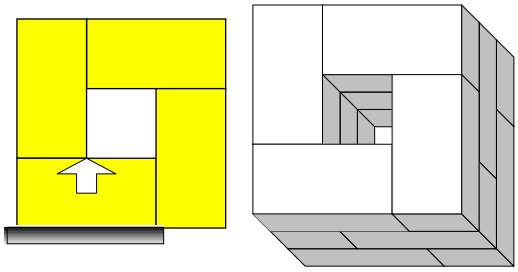
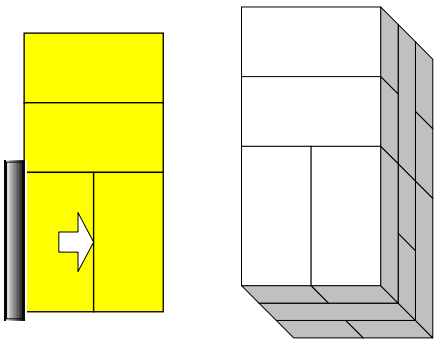
4

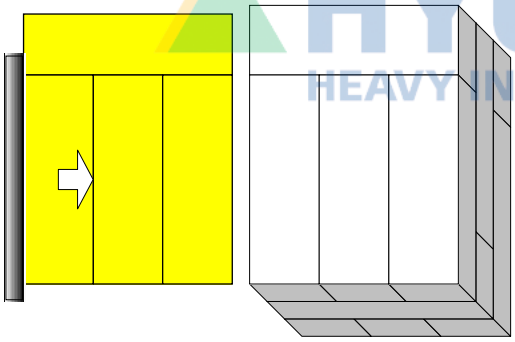
Pattern number 1



Pattern number 2



Pattern number 3



Pattern number 4

Pattern number 5

Pattern number 6

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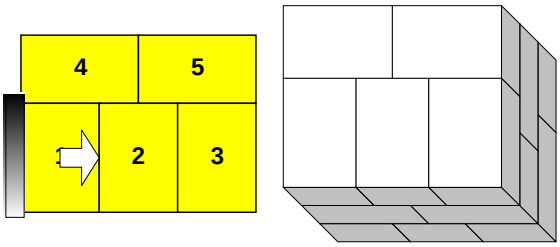
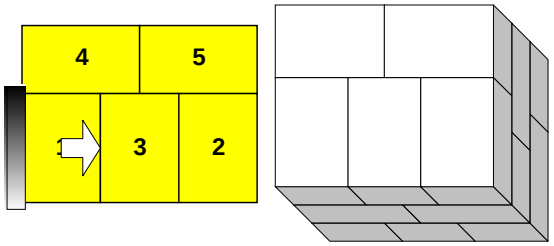
5

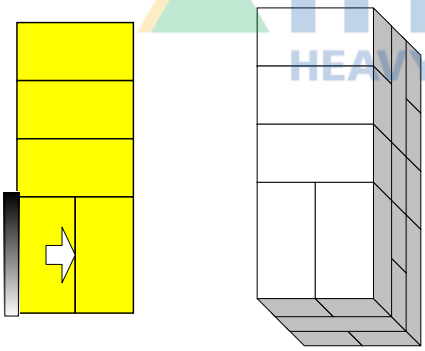
Pattern number 1



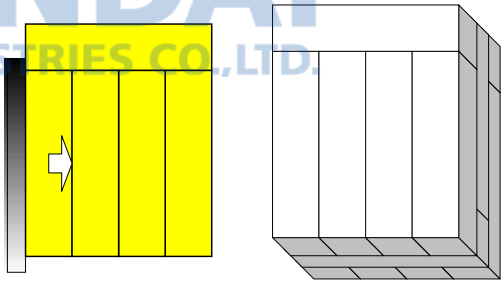
Pattern number 2



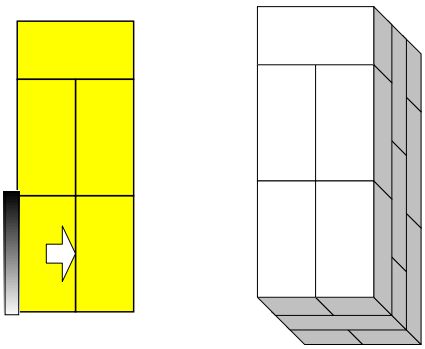
Pattern number 3



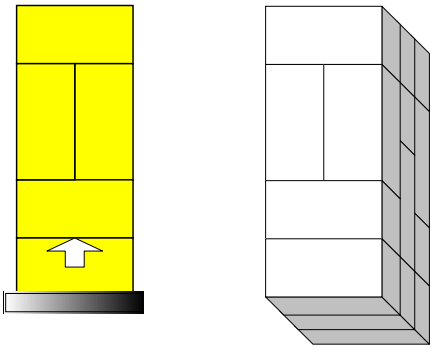
Pattern number 4



Pattern number 5



Pattern number 6



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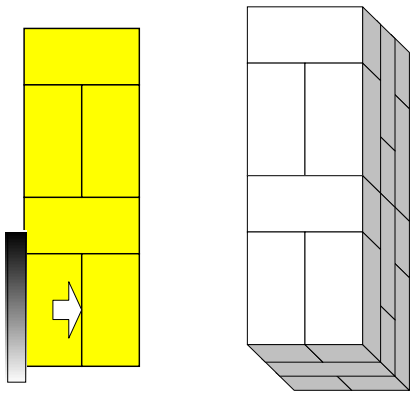
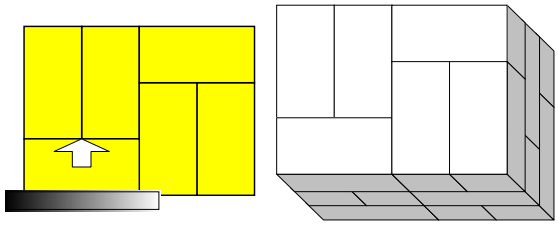
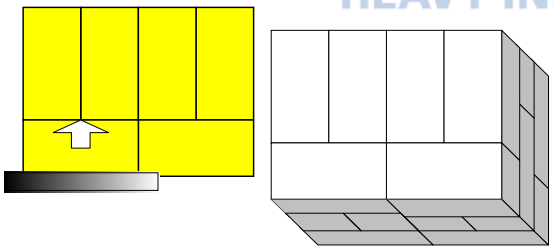
Pattern number 1



Pattern number 2



Pattern number 3



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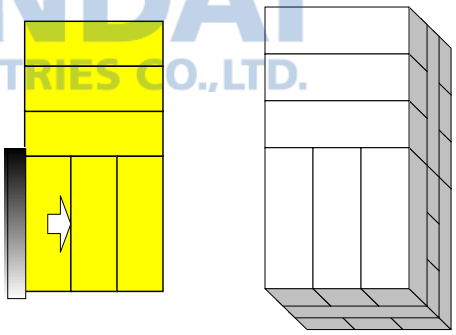

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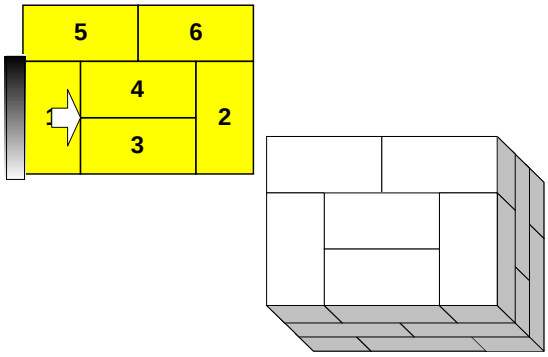

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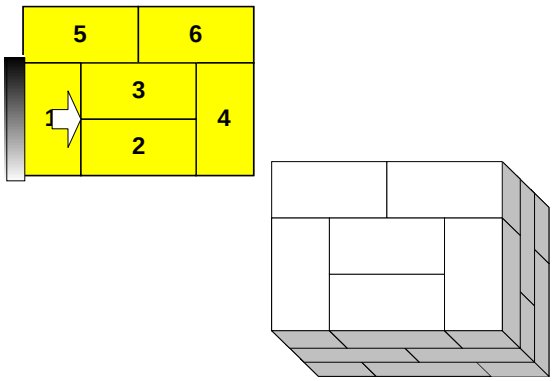

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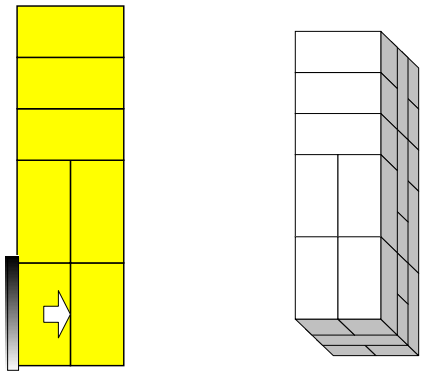
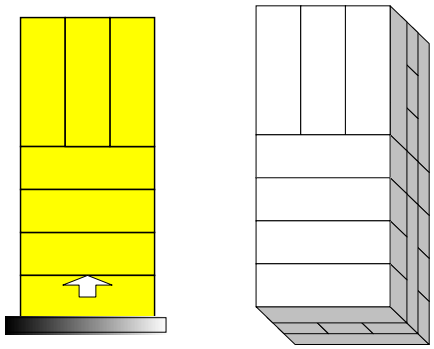
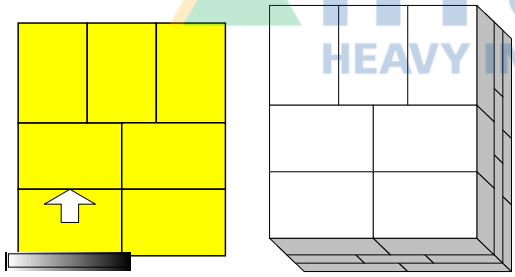
Pattern number 1



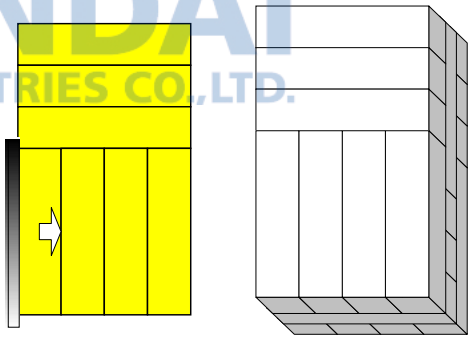
Pattern number 2



Pattern number 3



Pattern number 4



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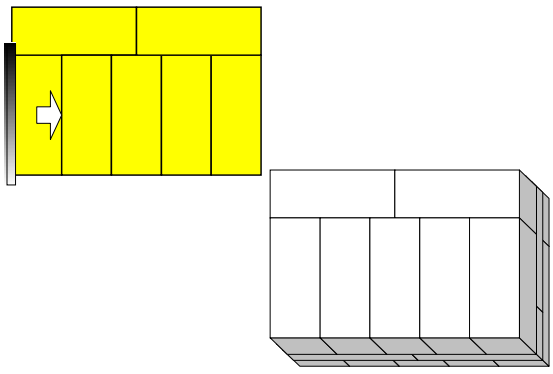
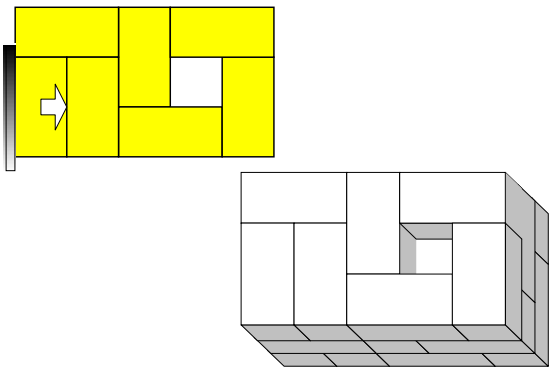


Pattern number 6



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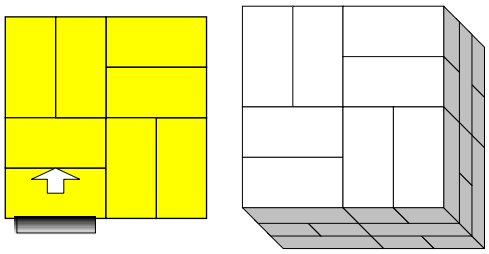
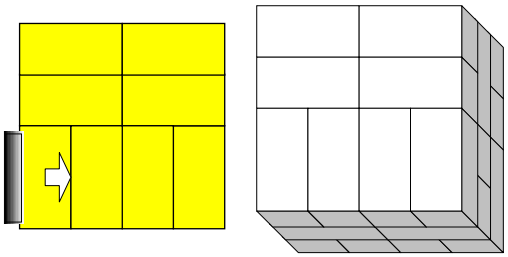
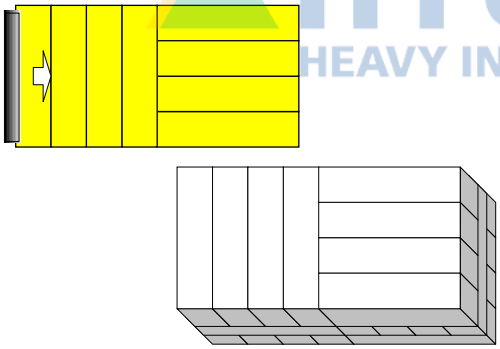
Pattern number 1



Pattern number 2



Pattern number 3



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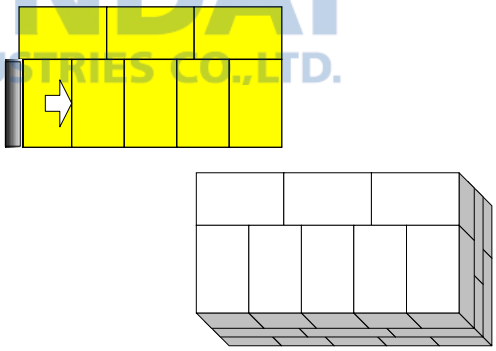
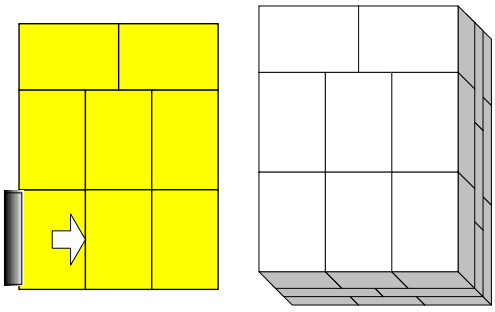
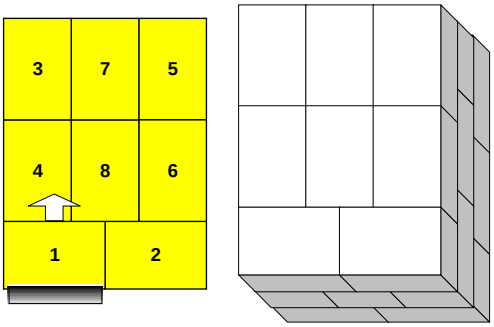


Pattern number 5



Pattern number 6



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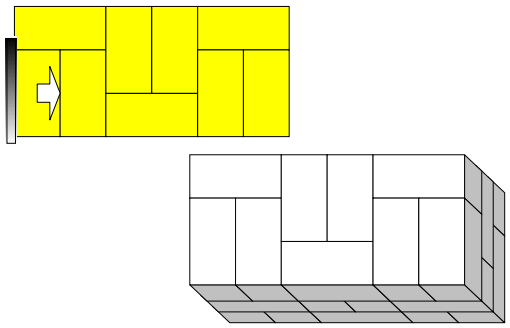
Pattern number 1



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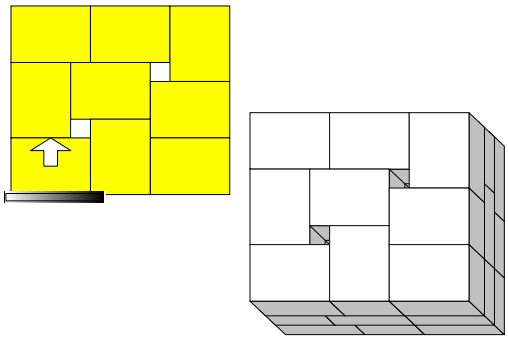

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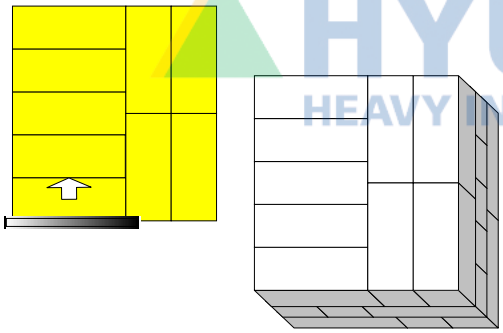

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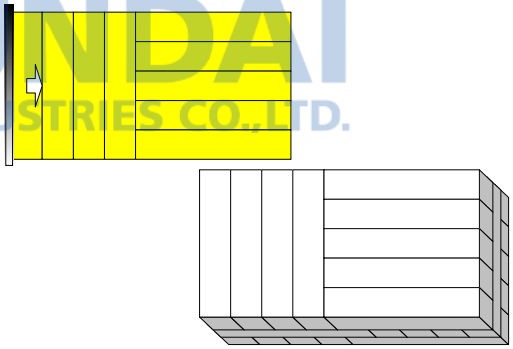

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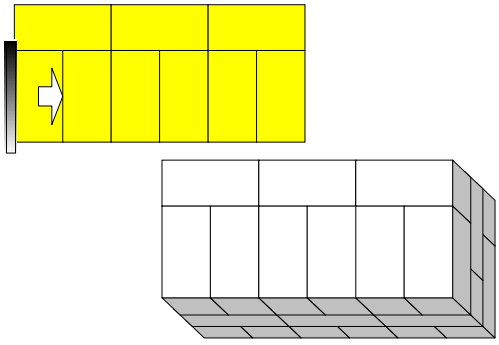
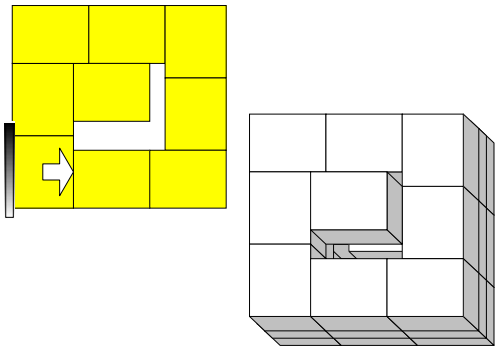


Pattern number 6



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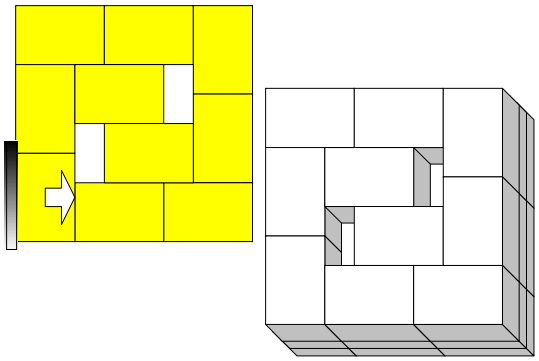
Pattern number 1



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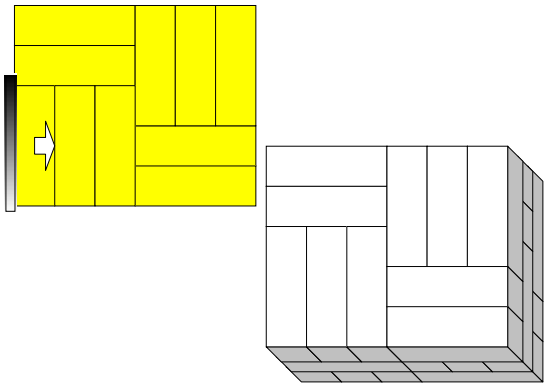

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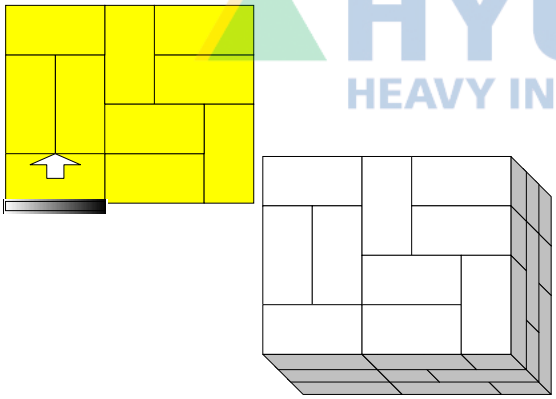

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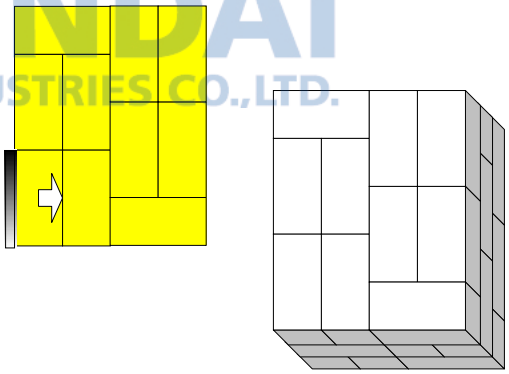

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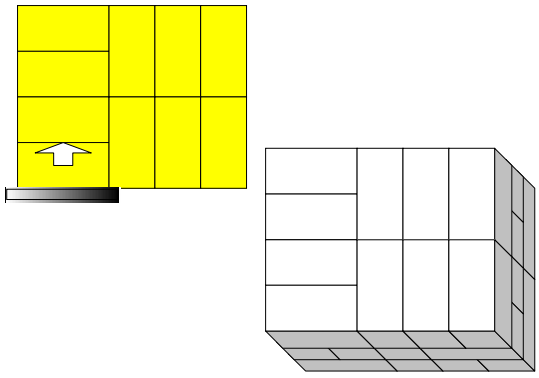

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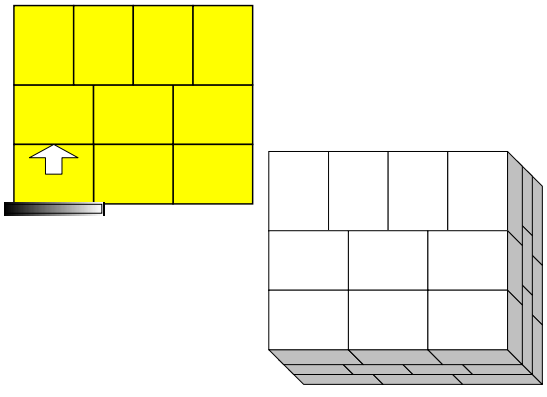

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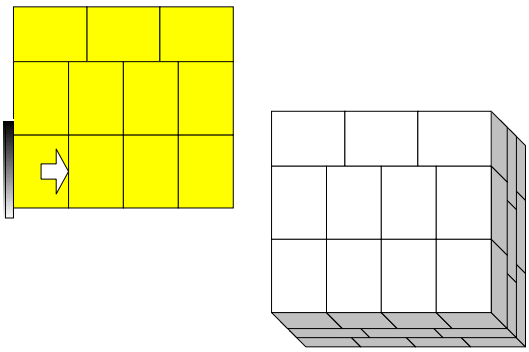
Pattern number 1



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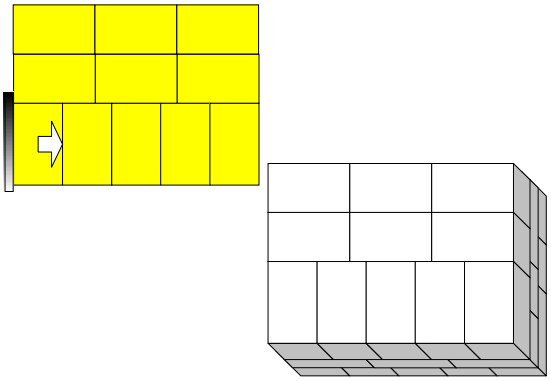

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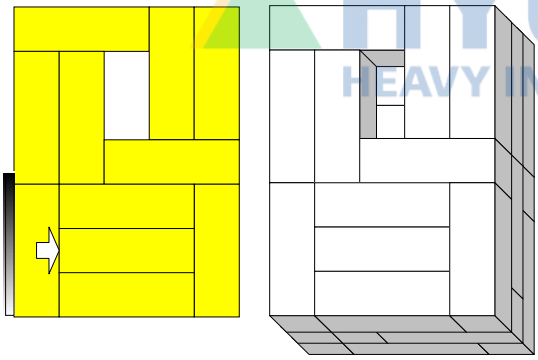

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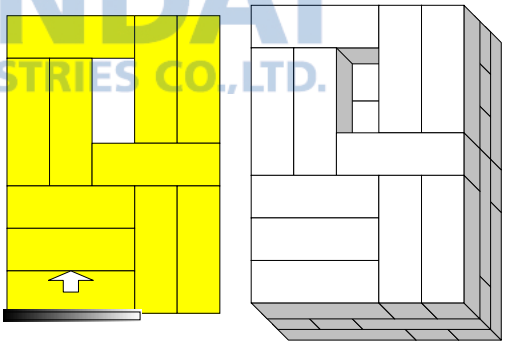

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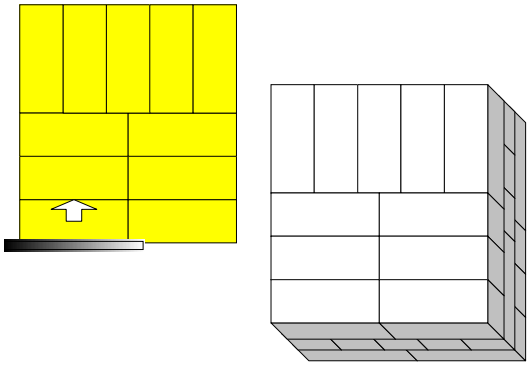

Pattern number 6

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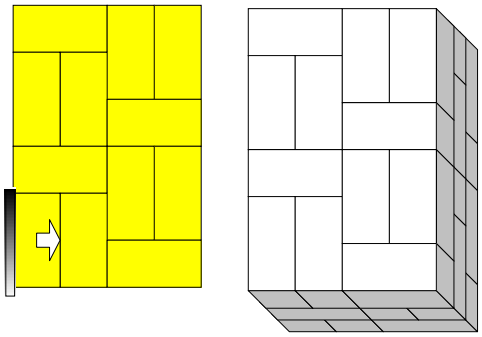
Pattern number 1



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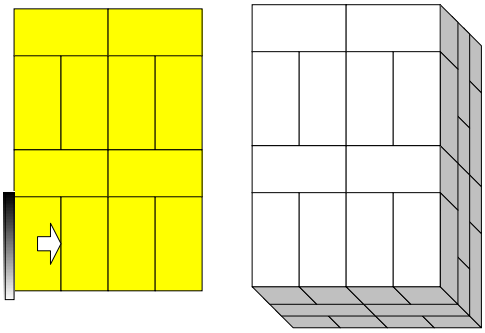

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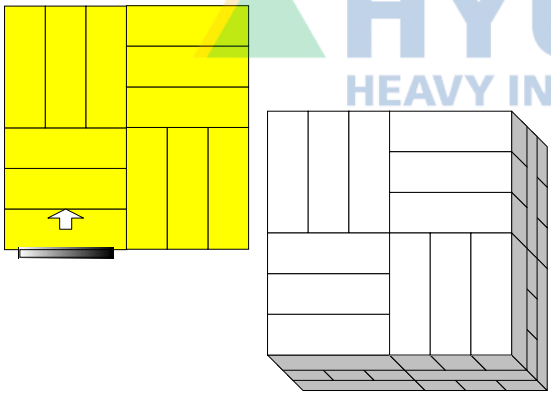

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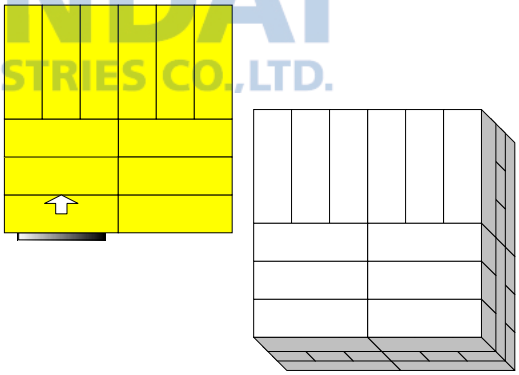

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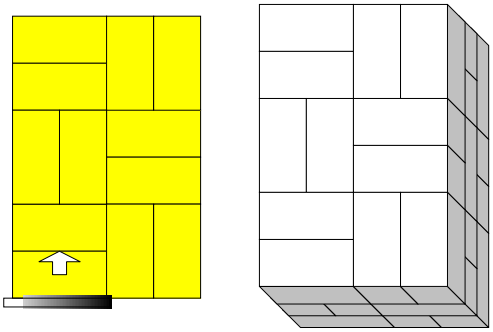

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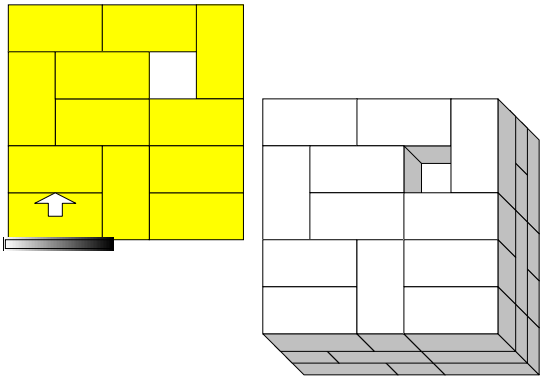

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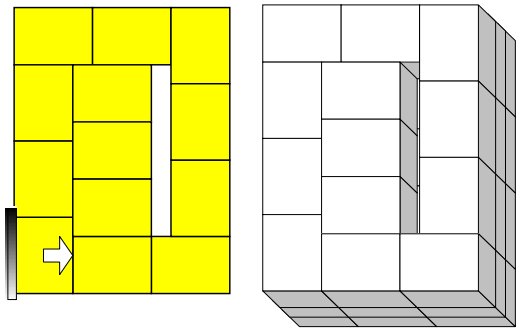
Pattern number 1



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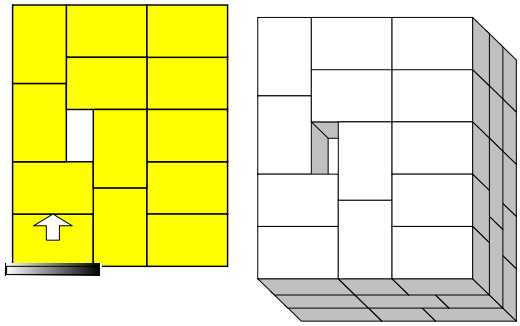

Pattern number 3

Pattern number 4

Pattern number 5

Pattern number 6

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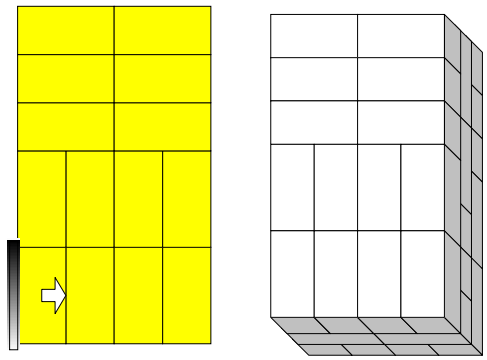
Pattern number 1



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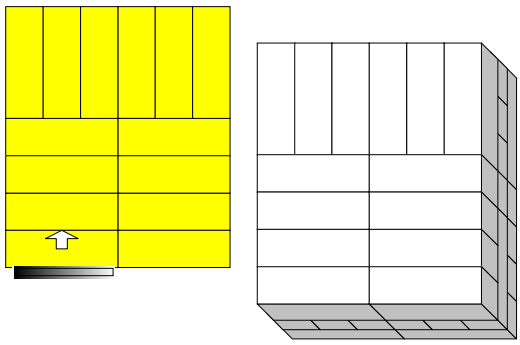

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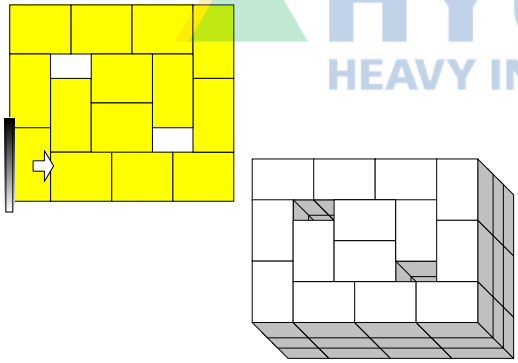

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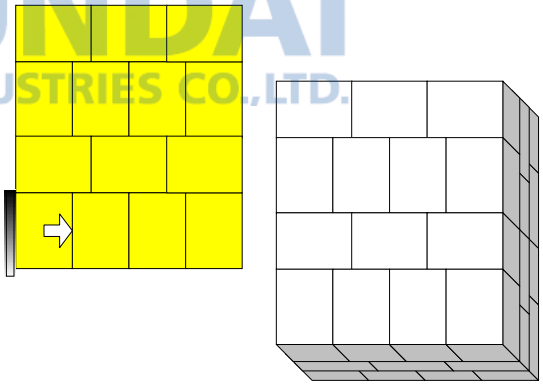

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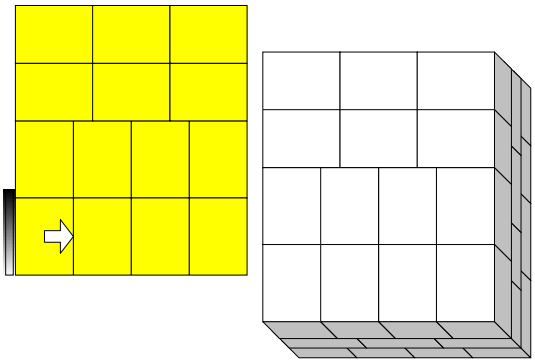

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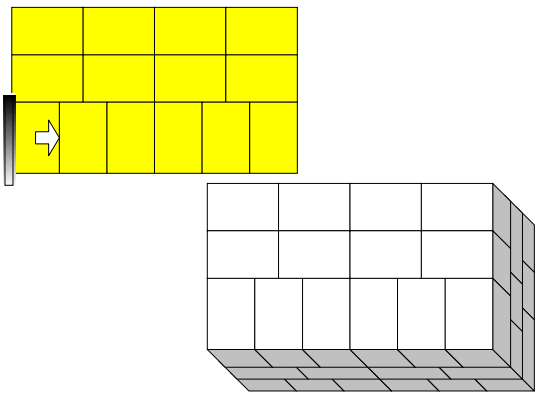

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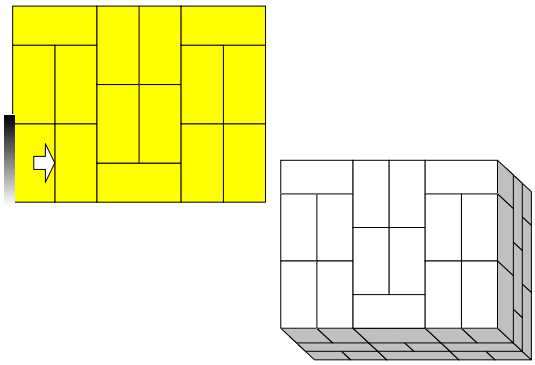
Pattern number 1



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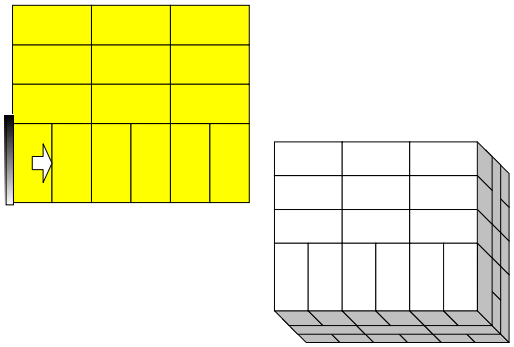

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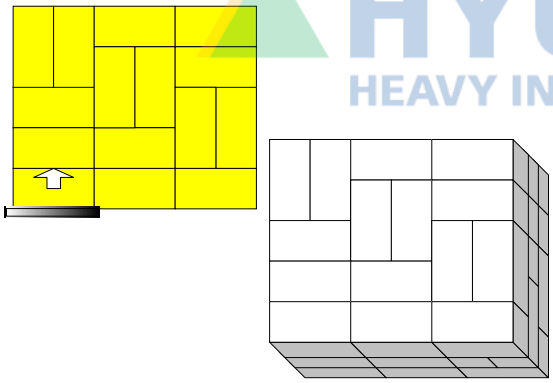

Pattern number 4

Pattern number 5

Pattern number 6

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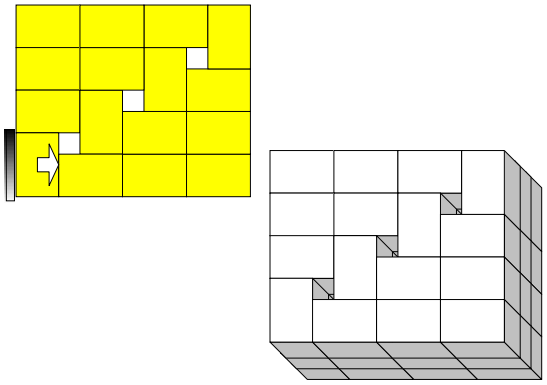
Pattern number 1



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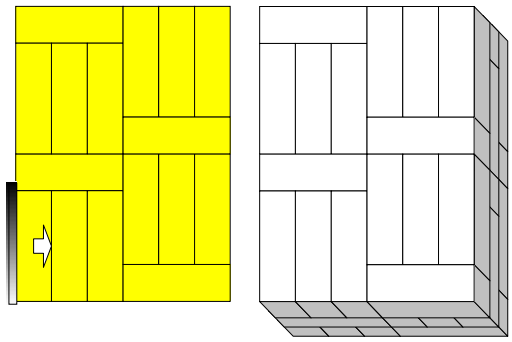

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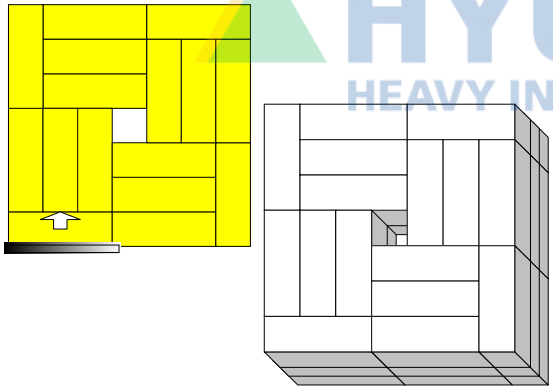

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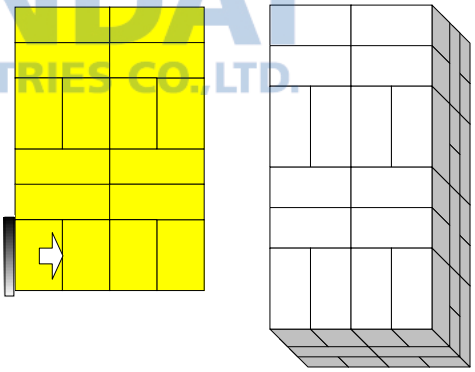

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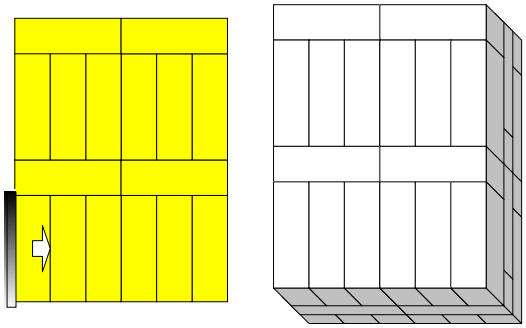

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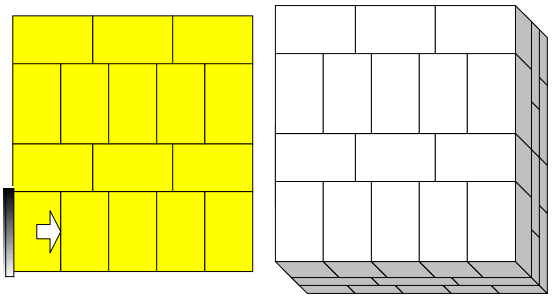

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17

Pattern number 1

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NOT AVAILABLE!

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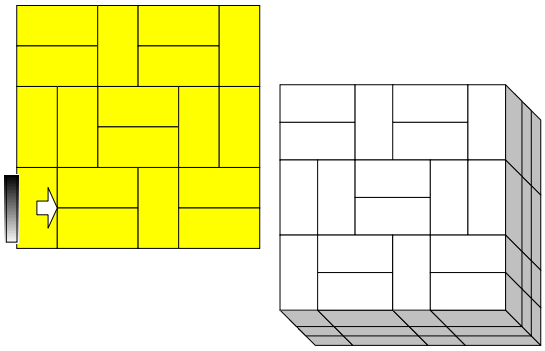
18

Pattern number 1



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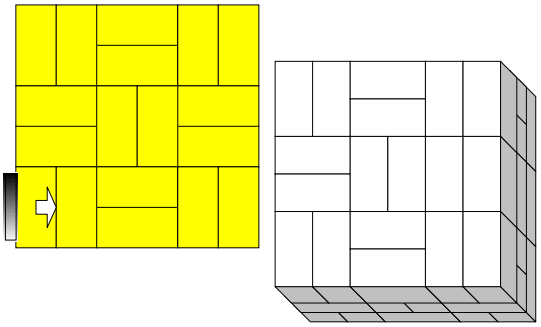

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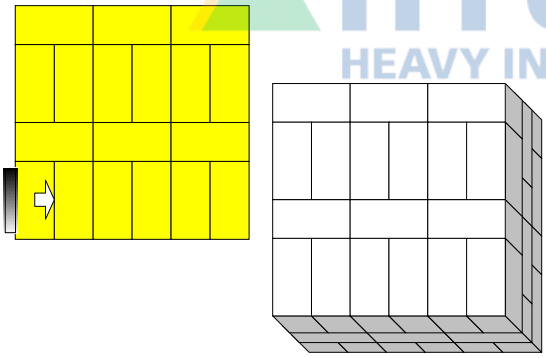

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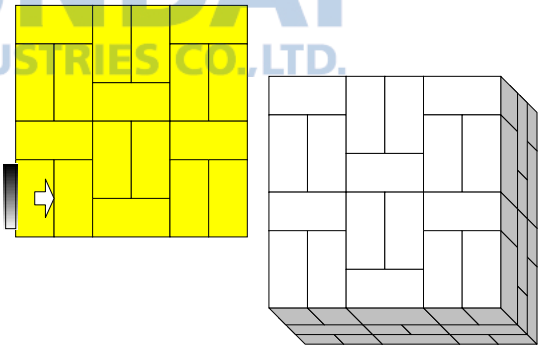

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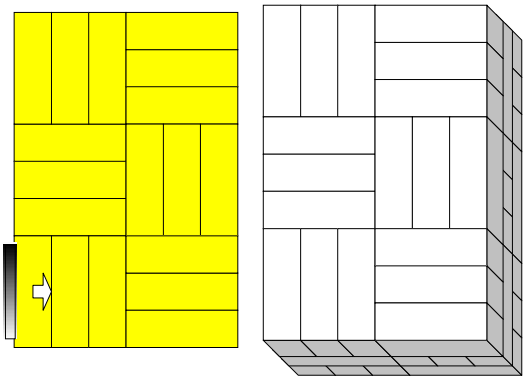

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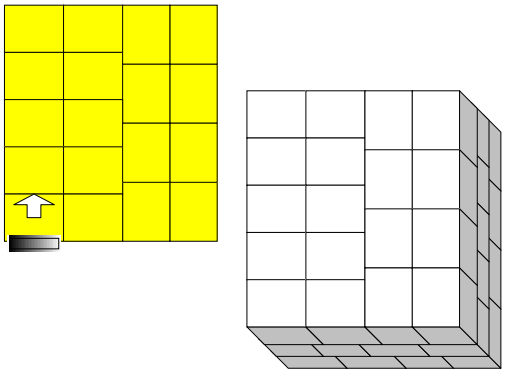

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19

Pattern number 1

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Pattern number 4

Pattern number 5

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NOT AVAILABLE!

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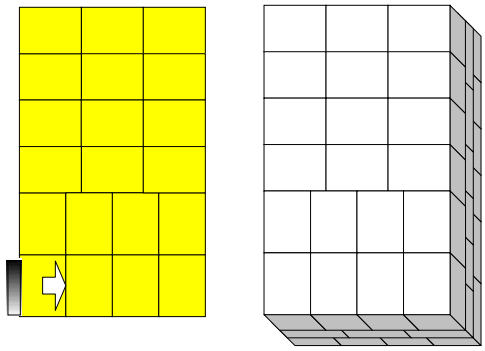
20

Pattern number 1



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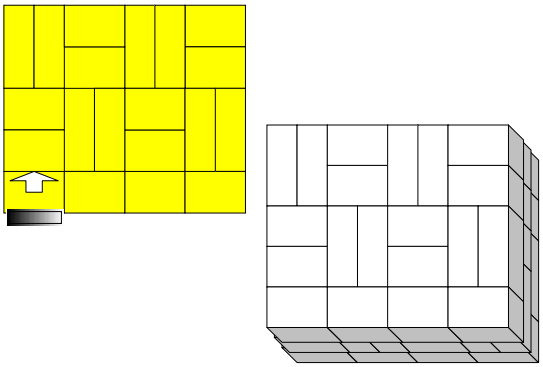
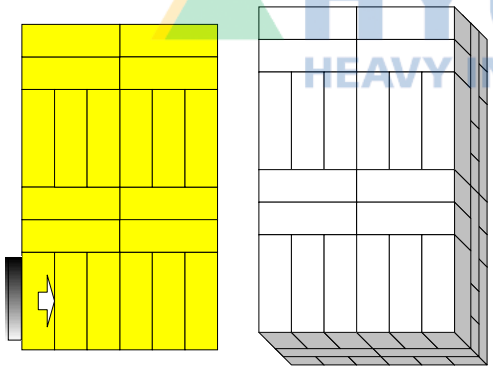


Pattern number 3



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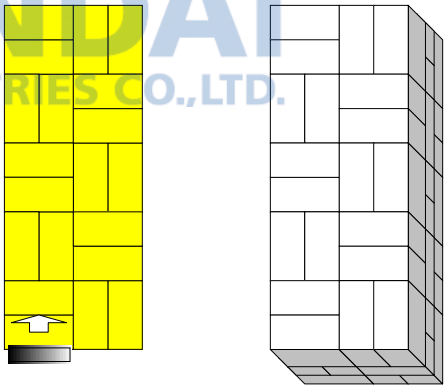

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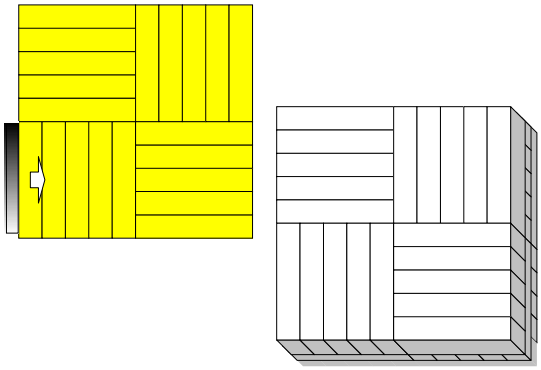

Pattern number 6

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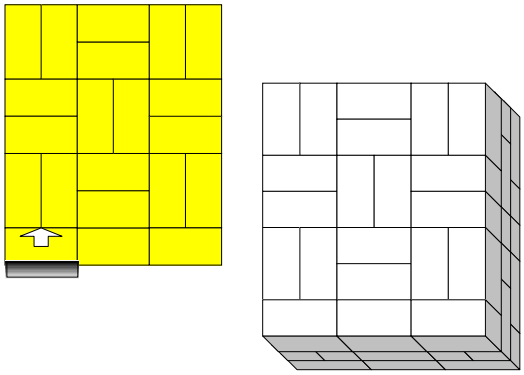
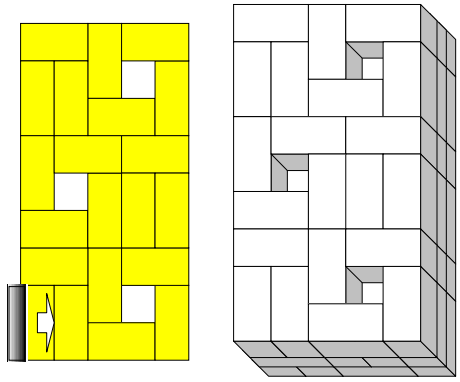
Pattern number 1



Pattern number 2



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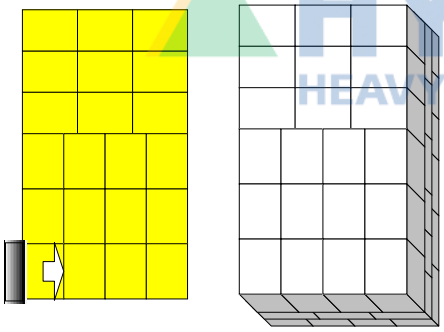

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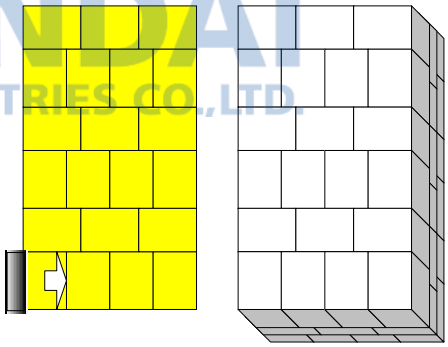

Pattern number 5

Pattern number 6

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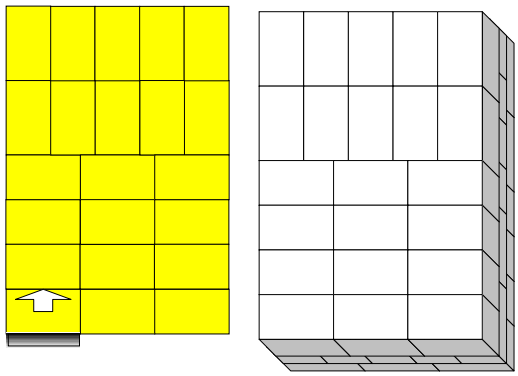
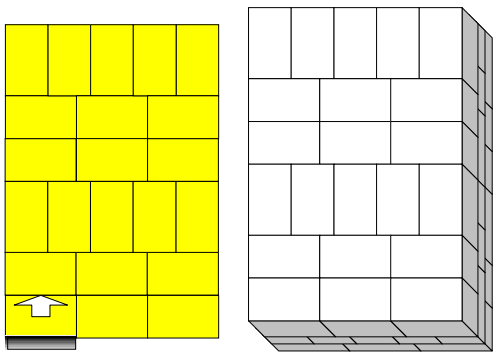
Pattern number 1



Pattern number 2



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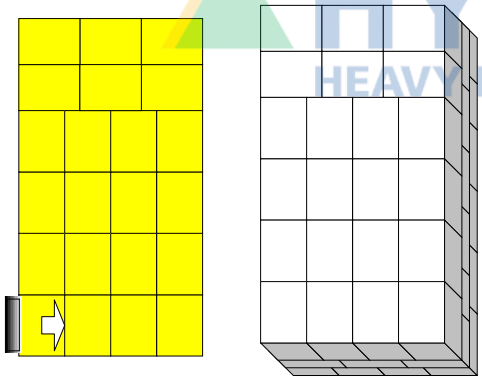

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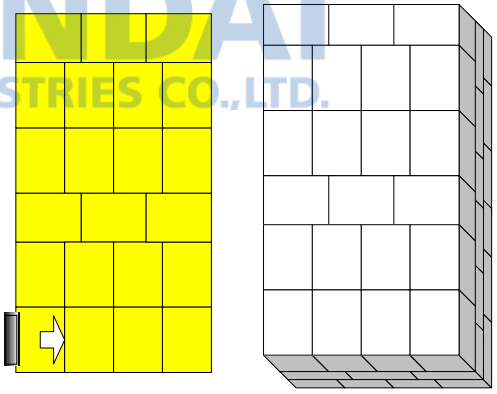

Pattern number 5

Pattern number 6

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Pattern number 1

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Pattern number 4

Pattern number 5

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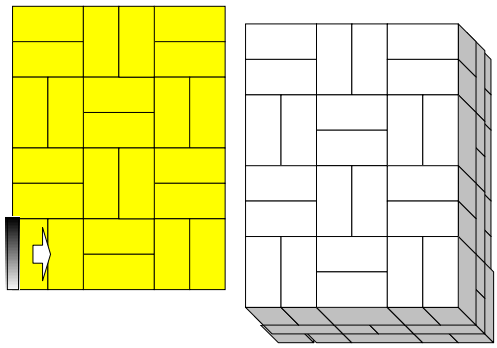
Pattern number 1



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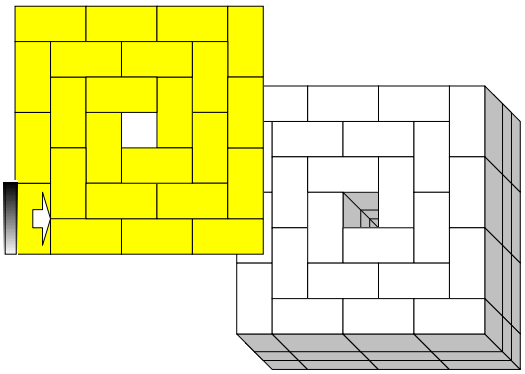

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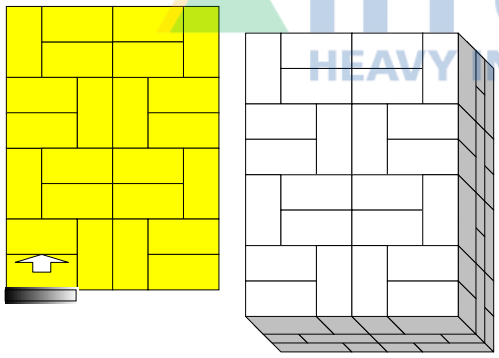

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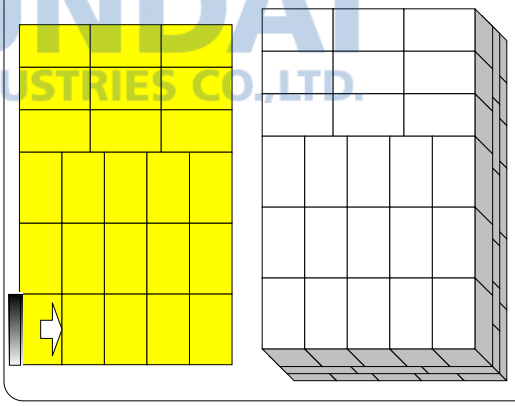

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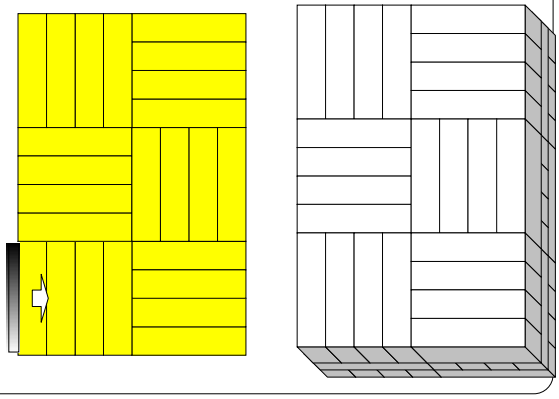

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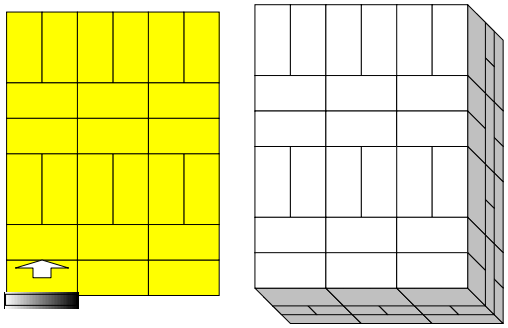

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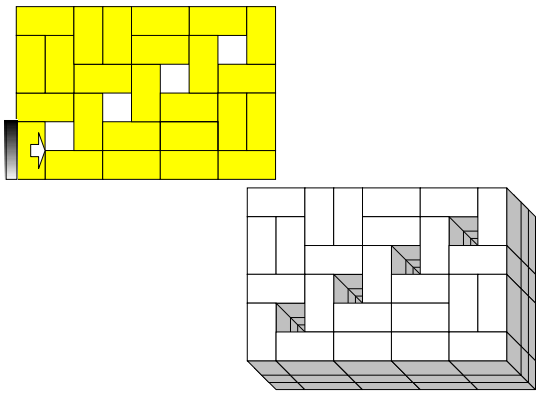
Pattern number 1



Pattern number 2

Pattern number 3

Pattern number 4

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Pattern number 5

Pattern number 6

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