FANUC Robot series

R-30*i*A/R-30*i*B/R-30*i*B Plus CONTROLLER

RemovalTool

OPERATOR'S MANUAL

B-84354EN/01

ORIGINAL INSTRUCTIONS

Thank you very much for purchasing a FANUC robot.

Before using the robot, be sure to read the, *FANUC Robot series SAFETY HANDBOOK (B-80687EN)* and understand its contents.

The products in this manual are controlled based on Japan's “Foreign Exchange and Foreign Trade Law”. The export from Japan may be subject to an export license by the government of Japan. Further, re-export to another country may be subject to the license of the government of the country from where the product is re-exported. Furthermore, the product may also be controlled by re-export regulations of the United States government. Should you wish to export or re-export these products, please contact FANUC for advice.

In this manual, we endeavor to include all pertinent matters. There are, however, a very large number of operations that must not or cannot be performed. Please assume that any operations that are not explicitly described as being possible are not possible.

SAFETY PRECAUTIONS

This chapter describes the precautions which must be followed to enable the safe use of the robot. Before using the robot, be sure to read this chapter thoroughly.

For detailed functions of the robot operation, read the relevant operator's manual to understand fully its specification.

For the safety of the operator and the system, follow all safety precautions when operating a robot and its peripheral equipment installed in a work cell. For safe use of FANUC robots, you must read and follow the instructions in the *FANUC Robot series SAFETY HANDBOOK (B-80687EN)*.

PERSONNEL

Personnel can be classified as follows:

Operator:

- Turns the robot controller power ON/OFF
- Starts the robot program from the operator panel

Programmer or Teaching operator:

- Operates the robot
- Teaches the robot inside the safeguarded space

Maintenance technician:

- Operates the robot
- Teaches the robot inside the safeguarded space
- Performs maintenance (repair, adjustment, replacement)

- The operator is not allowed to work in the safeguarded space.

- The programmer or teaching operator and maintenance technician are allowed to work in the safeguarded space. Work carried out in the safeguarded space include transportation, installation, teaching, adjustment, and maintenance.

- To work inside the safeguarded space, the person must be trained on proper robot operation.

Table s-1 lists the work outside the safeguarded space. In this table, the symbol "o" means the work is allowed to be carried out by the specified personnel.

Table s-1 Work Performed Outside the Safeguarded Space

	Operator	Programmer or Teaching Operator	Maintenance Technician
Turn power ON/OFF to Robot controller	o	o	o
Select operating mode (AUTO, T1, T2)		o	o
Select remote/local mode		o	o
Select robot program with teach pendant		o	o
Select robot program with external device		o	o
Start robot program with operator's panel	o	o	o

	Operator	Programmer or Teaching Operator	Maintenance Technician
Start robot program with teach pendant		○	○
Reset alarm with operator's panel		○	○
Reset alarm with teach pendant		○	○
Set data on teach pendant		○	○
Teaching with teach pendant		○	○
Emergency stop with operator's panel	○	○	○
Emergency stop with teach pendant	○	○	○
Operator panel maintenance			○
Teach pendant maintenance			○

During robot operation, programming and maintenance, the operator, programmer, teaching operator and maintenance engineer take care of their own safety using at least the following safety protectors:

- Use clothes, uniform, overall adequate for the work
- Safety shoes
- Helmet

DEFINITION OF SAFETY NOTATIONS

To ensure the safety of users and prevent damage to the machine, this manual indicates each precaution on safety with **"WARNING"** or **"CAUTION"** according to its severity. Supplementary information is indicated by **"NOTE"**. Read the contents of each **"WARNING"**, **"CAUTION"** and **"NOTE"** before using the robot.

⚠ WARNING

Used if hazard resulting in the death or serious injury of the user will be expected to occur if he or she fails to follow the approved procedure.

⚠ CAUTION

Used if a hazard resulting in the minor or moderate injury of the user, or equipment damage may be expected to occur if he or she fails to follow the approved procedure.

NOTE

Used if a supplementary explanation not related to any of WARNING and CAUTION is to be indicated.

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APPENDIX

1 OVERVIEW

RemovalTool allows you to perform surface and edge finishing applications with a wide variety of FANUC robots using FANUC-supplied force control devices. RemovalTool software is an option and is used with the HandlingTool software.

RemovalTool supports the following kinds of force control devices:

- Active wrist
- Passive wrist
- Passive bench

RemovalTool software contains macros that can be used to communicate with the active force control devices. For example RemovalTool has commands to:

- Set and modify applied forces
- Automatically weigh the tool

It also contains two other useful functions for passive force devices:

- **Wheel wear compensation:**

  To compensate for the wear in the abrasive wheel during productions.
- **Tool weight compensation:**

  For passive devices to compensate for forces changing due to changing wrist orientation of the robot. It also compensates for gravity.

Teach pendant template programs are also provided for you to get started quickly and to understand the order in which the RemovalTool macros are used.

1.1 SYSTEM OVERVIEW

This section contains a flowchart describing the sequence of operations you must follow in order to set up and use a RemovalTool application. See Figure 1.1.

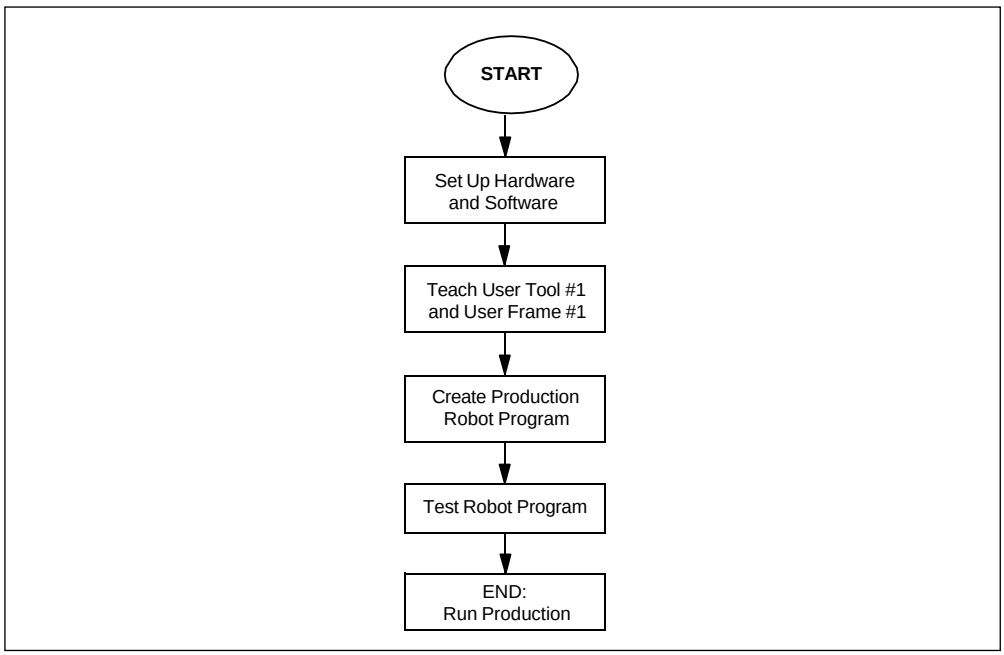

Figure 1.1 RemovalTool System Overview

1.1.1 Setup

RemovalTool software allows you to work directly with external devices such as force control devices and pneumatic spindles, using macros. The equipment must be set up before you begin your application. Other kinds of setup include tools and frames. Certain numeric and position registers must also be set up prior to operation.

Refer to Chapter 2, SETTING UP REMOVALTOOL for information on setting up RemovalTool.

1.1.2 Programming

An application program is a combination of instructions that, when executed in a sequence, will complete your edge or surface finishing application. Predefined macro instructions communicate with force devices and accomplish common tasks encountered in a force control system.

Template Programs

Refer to the program example that corresponds to the force control device you are using. The following three teach pendant programs are included with the RemovalTool software:

- Active wrist program `ACTVWTMP.TP`
- Passive wrist program `PASSWTMP.TP`
- Passive Bench program `PASSBTMP.TP`

Refer to Chapter 2, SETTING UP REMOVALTOOL for more information about these template programs.

1.1.3 Testing

After you have set up RemovalTool and, if necessary, modified the template programs provided by FANUC, you must test your application to be sure it runs correctly. Refer to Section 4.1, TESTING A REMOVALTOOL PROGRAM for more information about testing your RemovalTool application.

Testing the application is an important step in creating a successful application. Be sure to test your program thoroughly before running it in production.

1.1.4 Running Production

Running production is the final step in executing your application. After you have set up RemovalTool and tested your program, press the **CYCLE START** button on the controller and the robot performs the RemovalTool operation. Refer to Section 4.4, PRODUCTION OPERATION for more information about running your RemovalTool application in production.

1.2 TERMS

Become familiar with the terms in this section in order to use RemovalTool effectively.

Force Control Devices

You must specify the kind of *force control device* used for the removal process. RemovalTool supports the following kinds of devices:

- Active wrist
- Passive wrist
- Passive bench

Other devices require approval by FANUC before they can be used with RemovalTool.

User Frame

Defining the *user frame* is required for the bench mount force control devices. It is used for wheel wear compensation calculations. Use the *three point method* to define the user frame.

Tool Frame

Defining the *tool frame* is required for wrist mount devices. Tool Frame #1 must be used. It is used for wheel wear and tool weight gravity compensation calculations. FANUC recommends that you use the *six point method* to determine both tool offset and tool orientation when you define the tool frame.

Command Force

The *command force* is the force applied by the tool medium to the contact point on the surface of the workpiece. The RemovalTool software automatically takes into account the tool weight and tool orientation, and maintains the command force.

Tool Medium

The *tool medium* is the abrasive medium used during removal. Tool media can be of wheel, disc, or cup type. RemovalTool needs to now the type of medium used to determine if it can execute and calculate wheel wear. RemovalTool does not calculate wheel wear for disc type media.

Tool Weight

The *tool weight* is the weight of the current tool in use. It is used to compensate for tool weight against gravity for any tool orientation. The tool weight can be determined manually or automatically, depending on the force control device being used. You must provide accurate weight information for the tool device being used. This includes the weight of the following:

- Motor
- Tool medium
- Slide on which the motor is mounted
- Any other device used to mount the tool to the force control device

The active wrist force control device contains an option that weighs the tool automatically. This should be used whenever possible. For passive devices, the tool weight must be determined manually.

Force/Toolweight Compensation

Force compensation applies to only passive wrist mounted devices. The command force in an application is specified for the vertical orientation of the tool. In order to maintain the specified force between contact points, the force value must be modified at tool orientations other than the vertical orientation.

Tool Wear Compensation

Tool wear compensation applies to all the devices: active wrist, passive wrist, and passive bench mount. As the tool (abrasive wheel diameter for example) wears out, it needs to be detected and the Tool Frame must be modified by the tool wear amount. RemovalTool software provides a macro for calculating wheel wear.

2 SETTING UP REMOVALTOOL

2.1 HARDWARE INSTALLATION

You must install the force control devices before you can use them. Installation consists of the following:

- Mounting a motor
- Mounting the force device
- Pneumatic connections
- Active force device controller

2.1.1 Mounting The Motor

RemovalTool is compatible with various types of motors.

The motor shaft must be oriented parallel or perpendicular to the carriage axis.

When you mount a motor to the carriage, and you are using bracket other than those provided by FANUC, make sure that the design of the brackets will enhance process capability by increasing the stiffness of the carriage. Incorrectly designed brackets can deform the carriage mounting plate, causing problems with the internal slide rail alignment.

The force control devices require a double clamp method of mounting. See Figure 2.1.1. Even though this method is difficult to fabricate, it is nearly impossible to achieve less than optimal results when using it. The cap screws secure the bottom clamp to the carriage. This clamp acts as a stiffening rib. Tightening the upper cap screws forces the upper clamp against the motor, providing additional stiffness to the carriage plate.

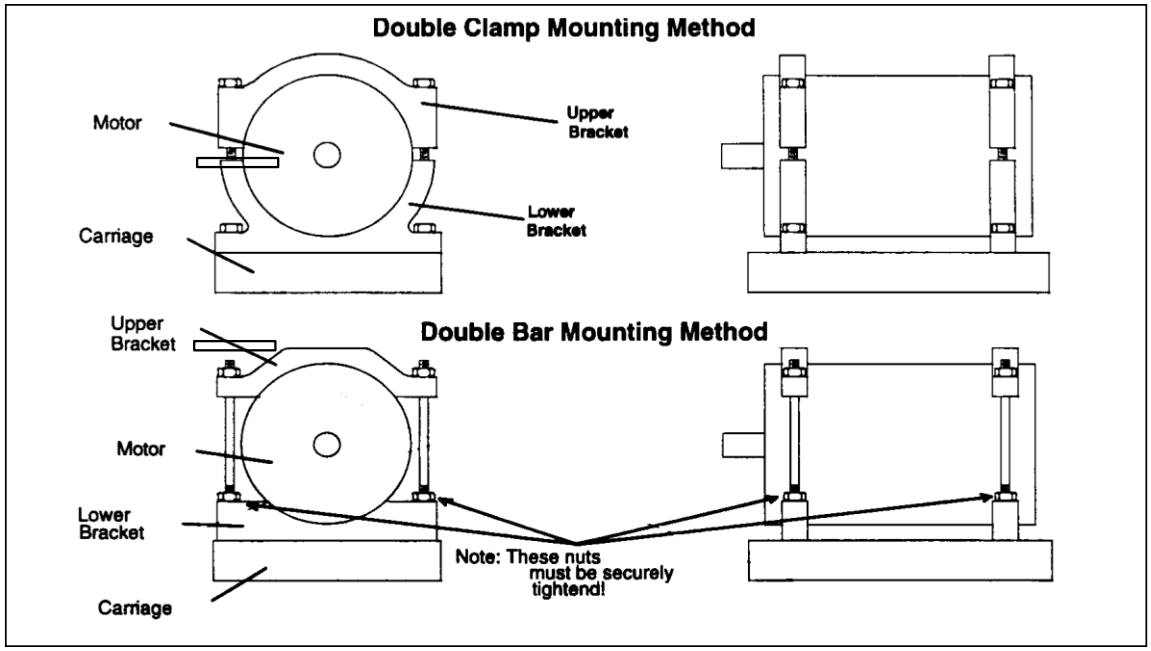

Figure 2.1.1 Double Clamp Mounting Method

The bolt pattern on the carriage plate is designed to facilitate motor installation in a number of configurations, providing secure attachment points that will not vibrate, causing the bolts to loosen.

> ⚠ **CAUTION**
>
> DO NOT use cap screws that extend beyond the threaded depth or damage WILL occur.

2.1.2 Mounting The Force Device

The force control device will be mounted differently, depending on which type of device you are using. The force control device can be directly attached to a robot, or fastened to a bench or floor stand. However you choose to install it, mount the device and its tool so that the positive (+) direction of the device is pointing to the extended direction and the negative (-) direction corresponds to the retracted direction.

Active Force Control Device

The active force control device uses a three hole mounting pattern. A minimum of three cap screws are required to attach the device securely to a fixture or robot tool mounting plate. See Figure 2.1.2 (a).

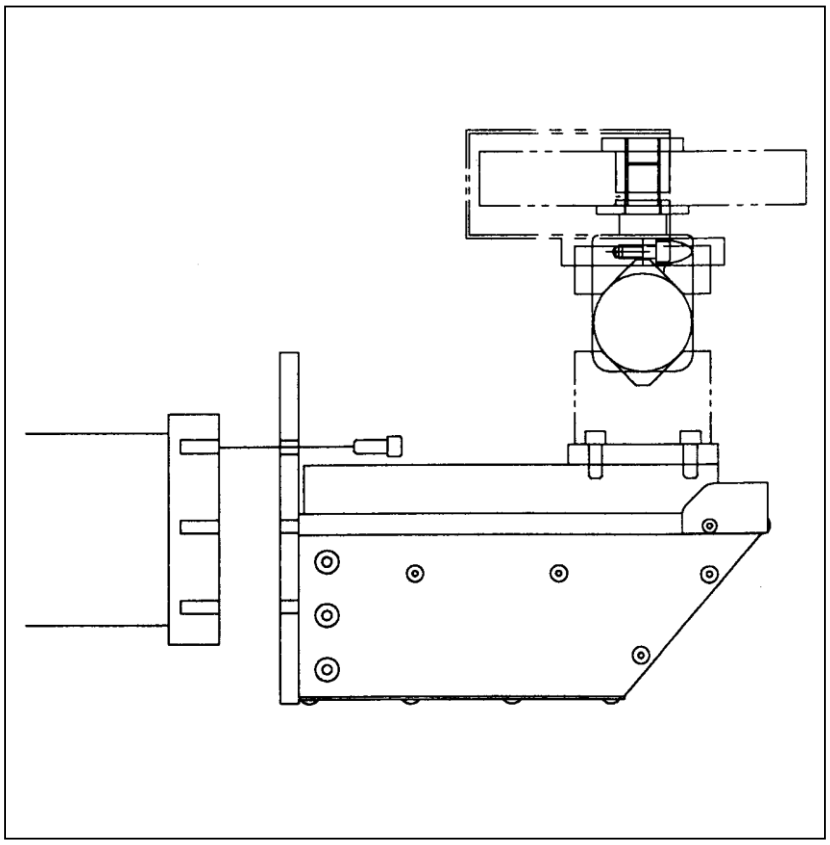

Figure 2.1.2 (a) Active Force Control Device Installation

Passive Force Control Device

Mount the passive force control device, via the mounting plate, to the robot. See Figure 2.1.2 (b). The control boxes are designed to mount to a typical FANUC robot arm. The pneumatic lines should not interfere with robot movement.

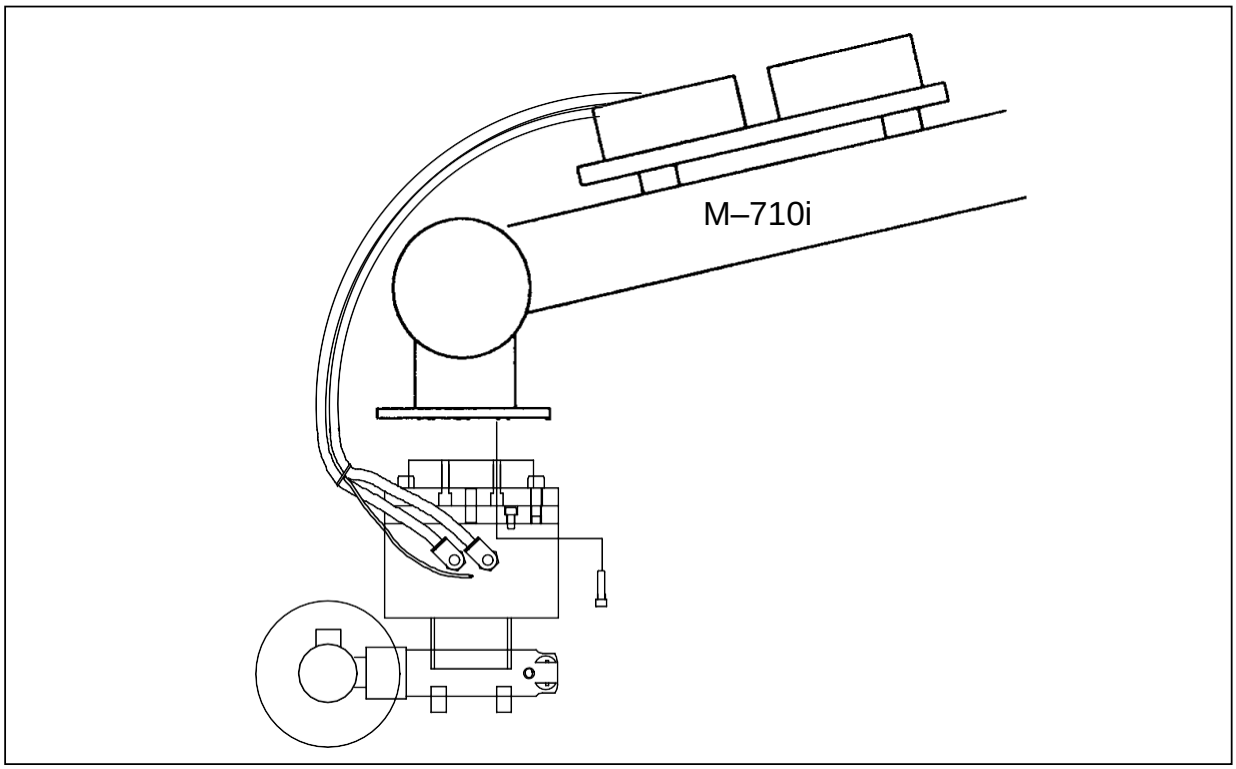

Figure 2.1.2 (b) Passive Force Control Device Installation

Passive Bench Mounted Device

The passive bench mounted device should be fastened to a bench or floor stand using the four 0.27 diameter mounting holes, located one on each corner of the base plate.

The mounting plate for the passive bench mounted device should be centered on the top surface of the device. See Figure 2.1.2 (c).

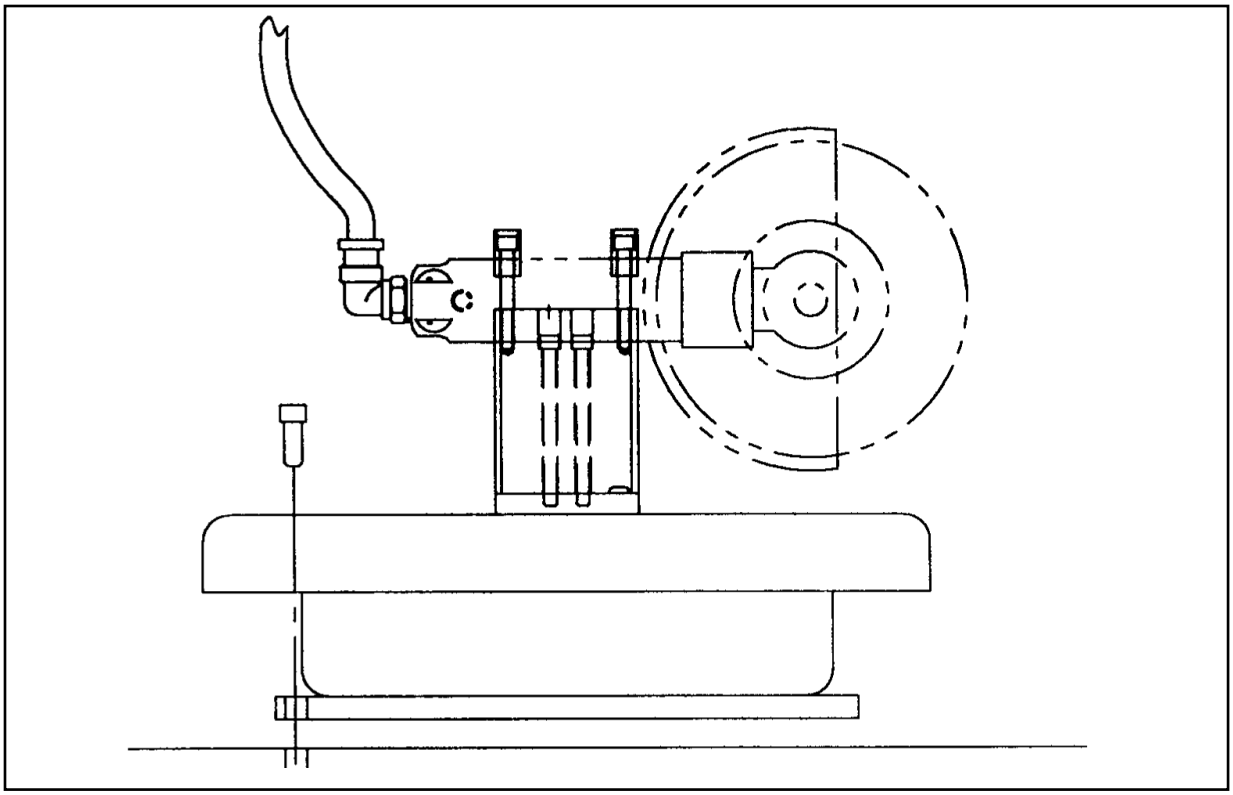

Figure 2.1.2 (c) Passive Bench Mounted Device Installation

2.1.3 Pneumatic Connections

In order to run properly, both the active and passive force control devices require the filtering of clean, dry air. For optimal system performance the air pressure should be maintained at 90 psi, with a minimum and maximum pressure tolerance of 80 psi and 100 psi respectively.

If water condensation is a problem in your air supply system, an air dryer device is required. Moisture inside the device will cause pneumatic failure.

The force control devices maintain a positive air pressure within the device housing to impede the infiltration of contaminated materials. It is important to provide a continuous compressed air supply to the device if the work environment is laden with air born contaminates. If the environment is clean during non-operational periods, you can shut off the air supply to the device using the standard shutoff valve.

Actuators Special Handling

The actuators used in the force control devices are designed and constructed to assure low friction and lead free operation.

> ⚠ **WARNING**
>
> Do not attempt to manipulate the pistons or cylinders. Otherwise, you could injure personnel or damage equipment. If you are having a problem with these parts, contact FANUC or the original equipment manufacturer.

The unit does not require lubrication. Lubrication will cause the unit to fail.

> ⚠ **WARNING**
>
> Do not pressurize the actuator prior to installation in the equipment. Otherwise, you could injure personnel or damage equipment.

Active Force Control Device

The active force control device requires a dry, 5 micron filter and unlubricated air supply with an optimal pressure of 90 psi. Filtered air is recommended in high speed flow control devices, used internally to the device, since they have very small orifices and cannot tolerate any foreign material in the air supply. The 5 micron filter is required to remove any particles in the air supply system. This filter should be located just before the line going to the force control device.

A minimum air pressure of 80 psi and a maximum air pressure of 100 psi must be maintained for the device to operate properly. Excessively low or high air pressures will cause inferior force control performance and instability.

The single supply line to the device is 1/4 inch in diameter and made of flexible nylon tubing. You should route the tubing to the device, such that there are no kinks and plenty of slack to allow for robot motion. Before you insert the air supply tubing into the force control device air fitting, open the supply valve to blow out any contaminates that might be in the line. Then push the supply line tubing into the self locking fitting. Charge the system with compressed air. Verify that there are no air leaks and that there is an air supply of 90 psi (Pressure tolerance: 80 psi minimum, 100 psi maximum).

The pneumatic supply system should be configure as shown in Figure 2.1.3.

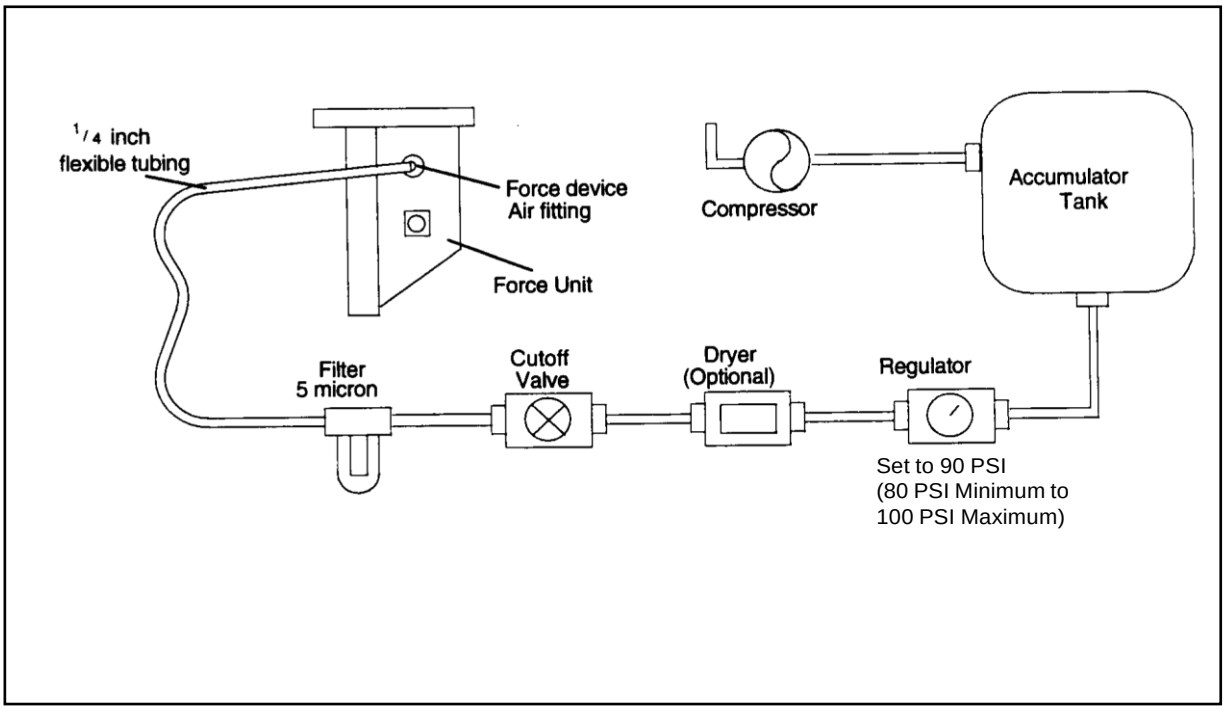

Figure 2.1.3 Active Force Control Device Pneumatic Connections

Passive Force Control Device

The gravity compensation function of Removal Tool requires the passive force control device has a double acting air cylinder and +/- air supply ports.

NOTE

Please see manufacturer recommendations for air supply requirements.

Route the air supply lines in a manner that does not restrict the motion of the complaint head.

External electro-pneumatic regulators with a 0-20 mA current range are required for Passive force devices, that do not have built-in electro-pneumatic valves.

One electro-pneumatic regulator is required per each air supply port used.

The gravity compensation function of Removal Tool has been optimized to use a SMC Valve (Part No. ITV2050–11N3N4) with 0–20 mA current range.

The electro-pneumatic regulators are control by a FANUC analog output card (ADA02A, FANUC Part No. A05B-2300–J460).

Refer to Figure 2.9 (c) for detail regarding setup of the electrical connection for the analog card and regulators.

The following items are recommended by FANUC for passive devices:

- (1) 5 slot model A I/O rack to suit controller
- (1) ADA02A Analog Output Card A03B-0819-C052
- (1) DC 24V Distribution Cable A05B-2601-J330

2.1.4 Active Force Device Controller

The active force device controller is mounted inside the controller and requires one connection to serial port JD17 located on the CPU controller. See Figure 2.1.4.

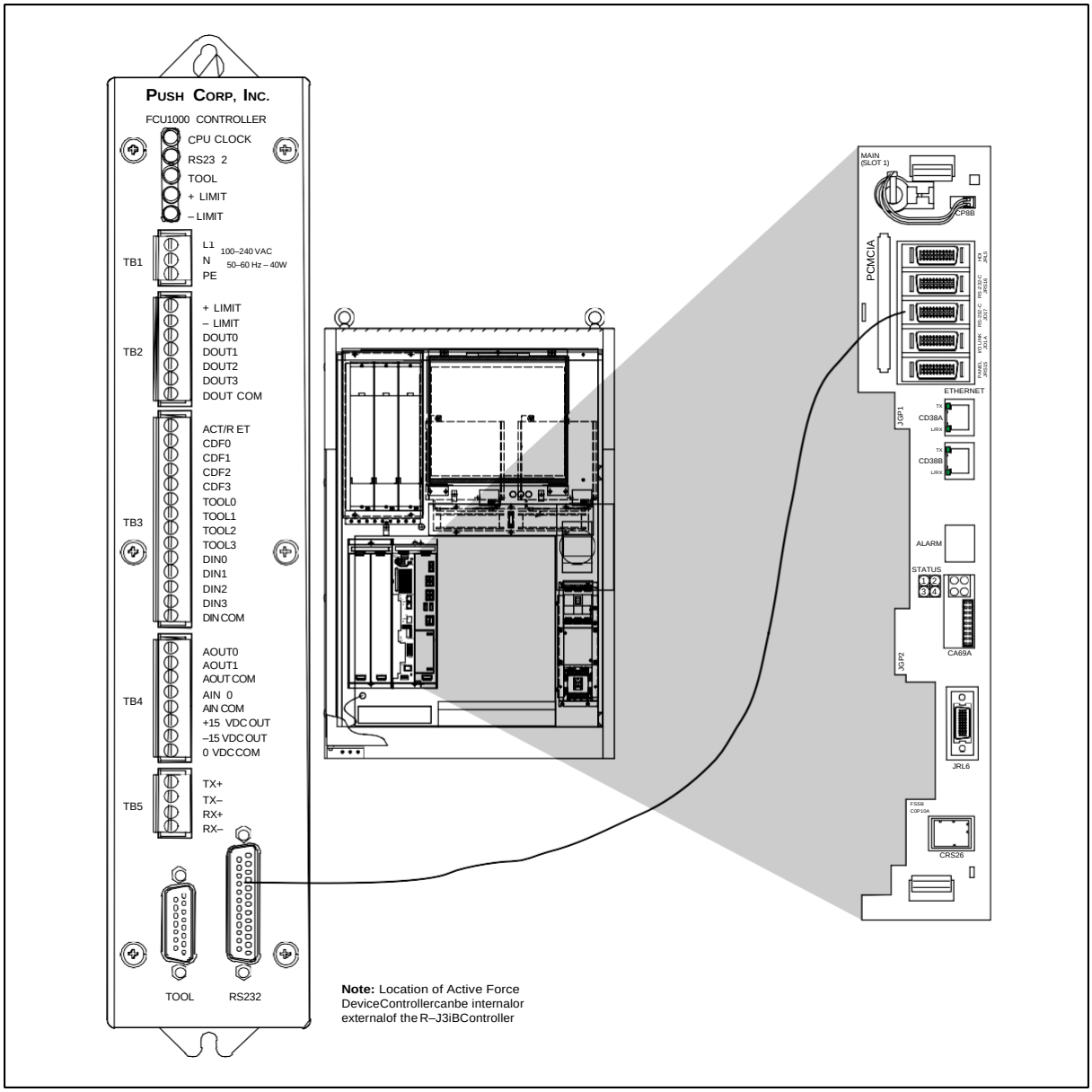

Figure 2.1.4 Active Force Device Controller

2.2 PORT SETUP FOR ACTIVE FORCE DEVICE CONTROLLER

Before you set up RemovalTool for the first time, you must verify that the P4 port setting is set to `No Use`. This is the serial port on the controller that is connected to the force controller. If this setting is wrong, RemovalTool software will not be able to communicate with the force control device. Use Section 2.2.1, Setting Up A Port to set up a port.

2.2.1 Setting Up A Port

Before you begin

Make sure the default device is set.

Procedure

1. Press **MENU**.
2. Select **SETUP**.
3. Press **F1, [TYPE]**.
4. Select **Port Init**. You will see a screen similar to the following.

```
SETUP Port Init
     Connector       Port      Comment
1 JRS16 RS-232-C       P2:    [Maintenance Cons]
2 JD17  RS-232-C       P3:    [KCL/CRT          ]
3 JD17 RS-422          P4:    [                 ]
```

5. Move the cursor to the port you want to set up and press **F3, DETAIL**. You will see a screen similar to the following.

```
SETUP Port Init
JRS16 RS-232-C          P2:
   1 Device              [Maintenance Cons]
   2 Speed(Baud rate)                [9600 ]
   3 Parity bit                      [None ]
   4 Stop bit                       [1bit  ]
   5 Time out value(sec)               [  0]
```

6. Select each item and press **F4, [CHOICE]**, to select the appropriate value.

> **NOTE**
>
> To indicate that you are not using a port, set the port to **No Use**. Set the port to **No Use** if you are performing a READ/WRITE from a KAREL program.

7. A device cannot be assigned to two ports. To move a device to another port, set the existing port to **No Use** and then assign the device to another port.
8. Perform a Cold start of the controller to implement the changes to the Port Init screen.

2.3 PERCH POSITION

RemovalTool provides a program called `PRGPERCH.TP` which is intended to move the robot to a home position in the cell. The home position must be taught in PR[10] for `PRGPERCH.TP` to work. It is

expected that PRGPERCH.TP will be called before executing the ADJUTOOL macro for wheel wear calculation.

2.4 NOMINAL UTOOL

If your application uses wrist-mounted devices, you must teach a nominal UTOOL frame for each individual tool mounted to the force control device. It is highly recommended that you use the 6-point method of teaching the UTOOL frame.

Refer to the *OPERATOR'S MANUAL (Basic Function) (B-83284EN)* or the *HandlingTool Setup and Operations Manual (MAROUHT9307191E)* for more information on setting up tool frames.

Gravity Compensation

The gravity compensation feature can only be used with passive devices that are able to apply force in opposing directions while using two cylinders. This feature uses the register assignment R[6] to set the direction of the slide. To operate properly, the positive slide direction of the passive wrist-mounted force device must be along the UTool frame -x direction when R[6]=0, or along the +z direction when R[6]=1. See Figure 2.4 (a) and Figure 2.4 (b) for detailed illustrations.

If your application has two tools mounted to your device, where one tool operates in the extended position and one tool operates in the retracted position, you need to change the UTool frame and direction by modifying the register assignment R[7] when changing from one tool to another.

NOTE

R[7]=0: Reverse force is off. R[7]=1: Reverse force in on.

Wheel Wear Compensation

The wheel wear calculation feature can be used with an active or a passive device, and it uses the register assignment R[15] to set the direction of the slide. It is also necessary to copy the UTool value into position register PR[1: Nominal UTool].

NOTE

For the wheel wear calculation feature to work on a passive device, a linear potentiometer must be installed inside the unit to monitor the carriage position.

For the wheel wear calculation feature to operate properly, the positive slide direction must be along the UTool frame +x direction when R[15]=1, along the +y direction when R[15]=2, or along the +z direction when R[15]=3. See Figure 2.4 (a) and Figure 2.4 (b) for detailed illustrations.

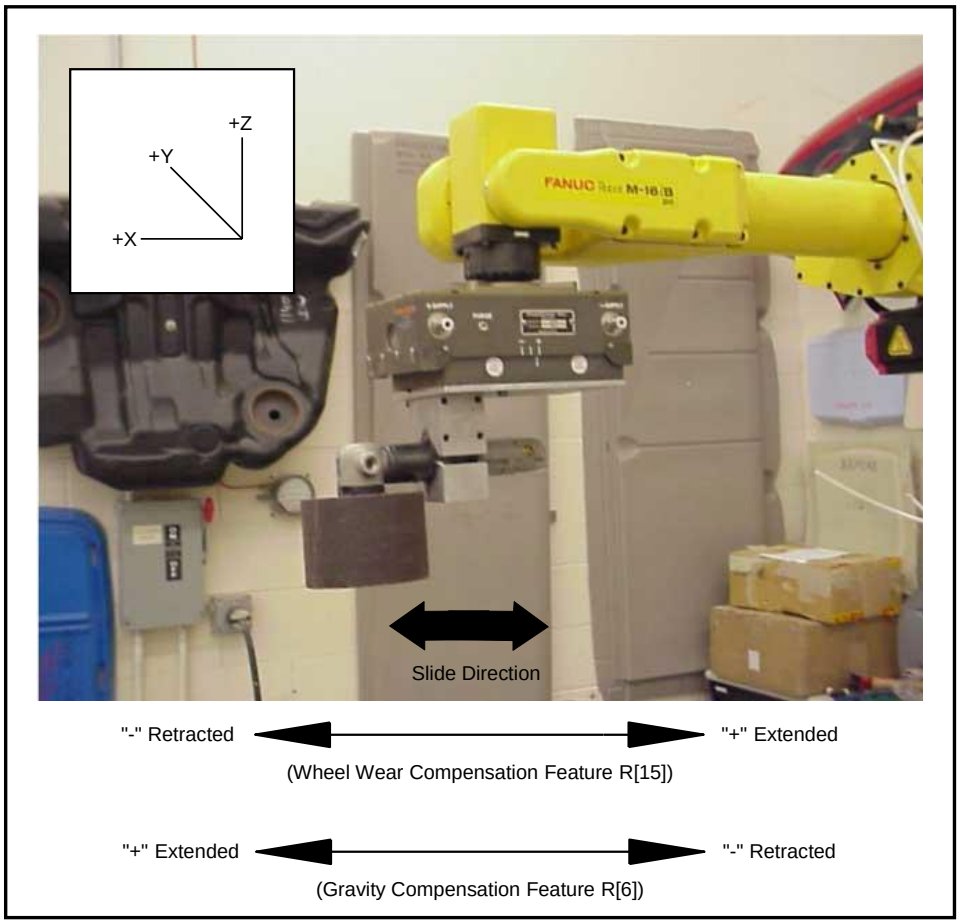

Figure 2.4 (a) X Axis Slide Orientation

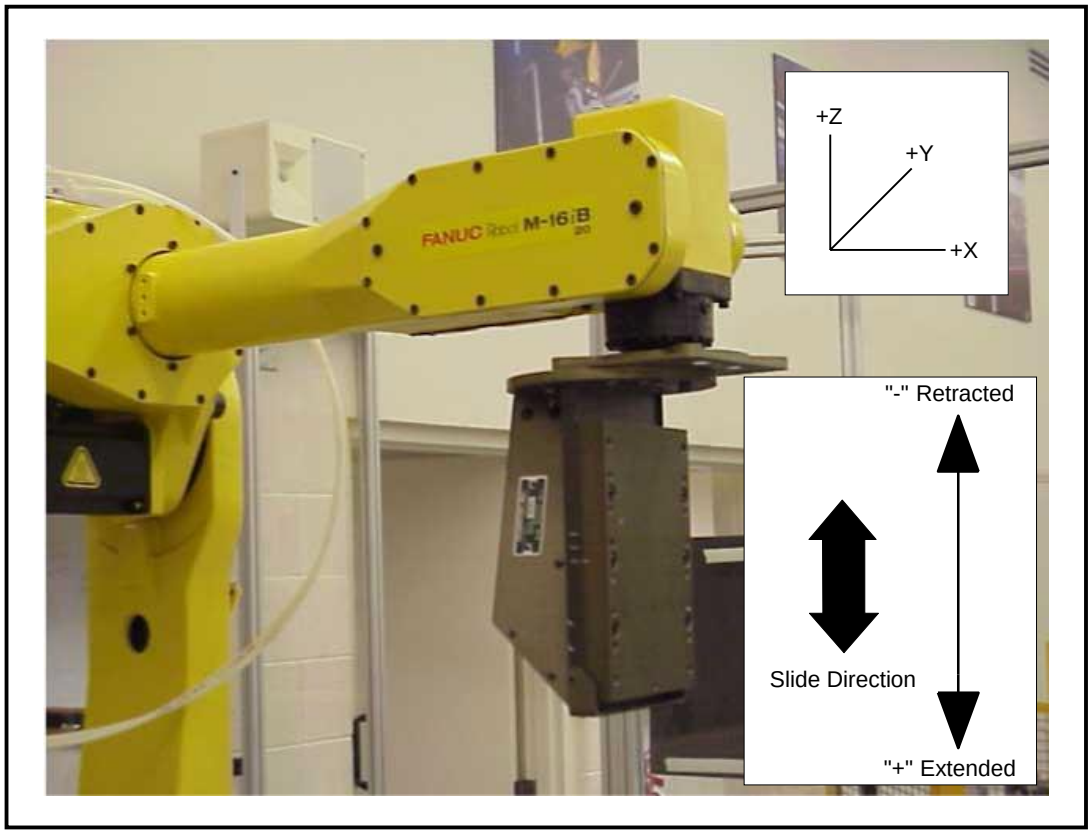

Figure 2.4 (b) Z Axis Slide Orientation

2.5 NOMINAL UFRAME

If your application uses bench mount devices, you must teach a nominal UFRAME which is required by the `ADJUST UFRAME` macro used for wheel wear calculation.

After you have done this, copy the UFrame value to PR[7:Nominal UFrame].

Refer to the *OPERATOR'S MANUAL (Basic Function) (B-83284EN)* or the *HandlingTool Setup and Operations Manual (MAROUHT9307191E)* for more information on setting up user frames.

2.6 SEARCH DISTANCE AND DIRECTION FOR WHEEL WEAR

The `ADJUST UTOOL` and `ADJUST UFRAME` macros use PR[2:Incr Search dist] to move the robot incrementally towards the part. The search direction is specified by entering values for x, y, z in PR[2]. For example, if you want to have a search direction parallel to the z in the robot world coordinates, you would enter -2 mm for z and zeros for x, y, w, p, r. This would make the robot move downwards towards the part in increments of 2 mm when the `ADJUST UTOOL` macro is executed.

2.6.1 Search Start Position

In order to determine wheel wear, teach a search start position using the guidelines below.

Then, periodically during production, call the program containing the search start position and the `ADJUST UTOOL` or `ADJUST UFRAME` macro.

Figure 2.6.1 (a) illustrates how to teach the search start position using the active wrist. When you teach the search start position, make sure that the slide direction is perpendicular to the surface of the part.

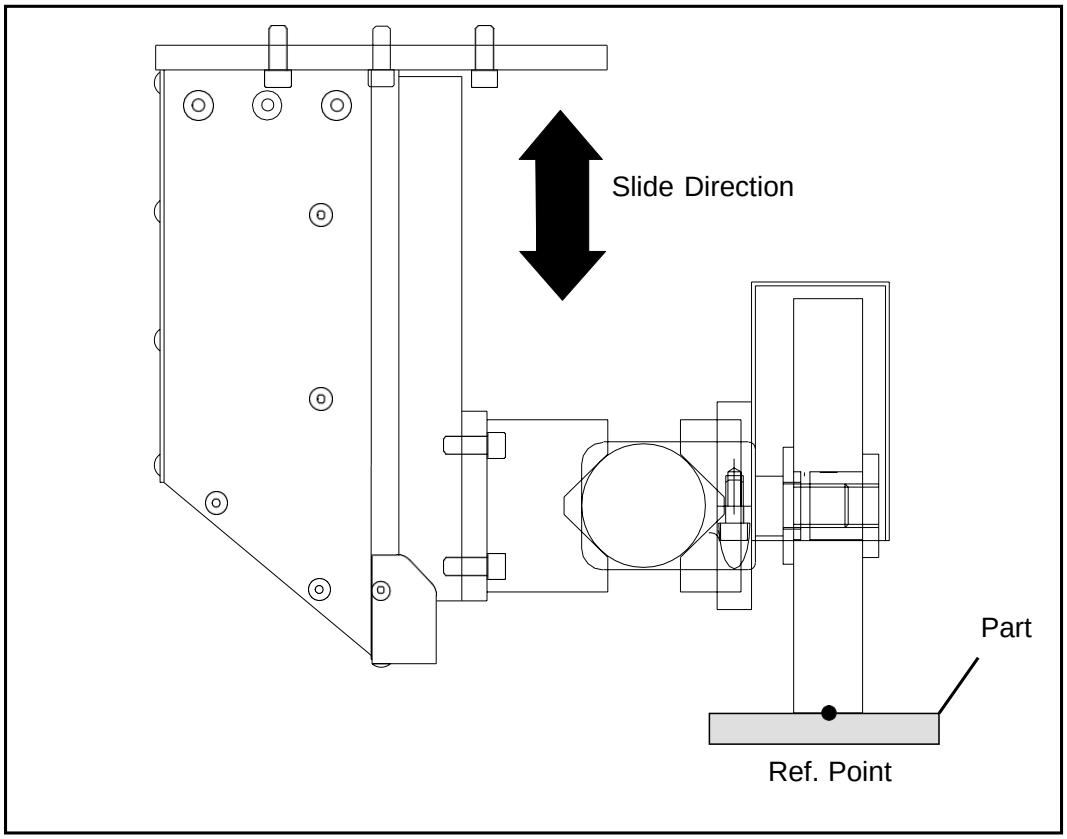

Figure 2.6.1 (a) Teach Search Start Position - Active Wrist

Figure 2.6.1 (b) illustrates how to teach the search start position using the passive wrist. When you teach the search start position, make sure that the slide direction is perpendicular to the surface of the part.

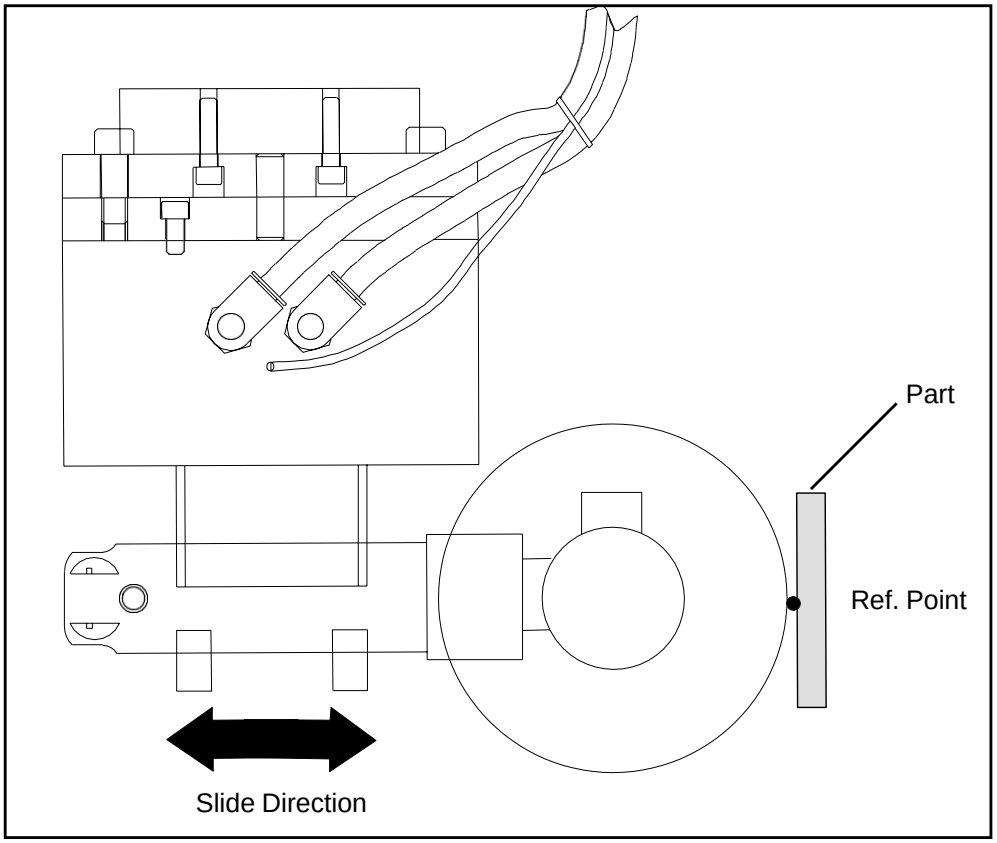

Figure 2.6.1 (b) Teach Search Start Position - Passive Wrist

Figure 2.6.1 (c) illustrates how to teach the search start position using the bench mounted device. When you teach the search start position, make sure that the part is perpendicular to the wheel or disc, and at the center point of the wheel or disc.

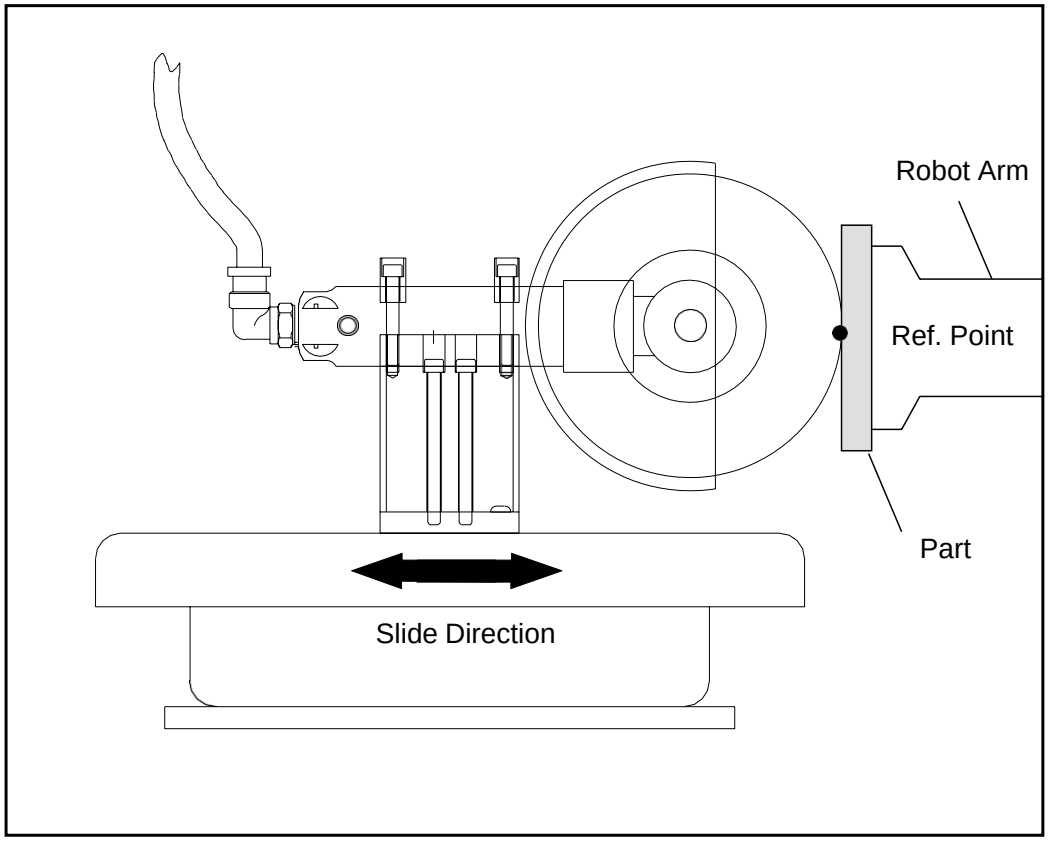

Figure 2.6.1 (c) Teach Search Start Position - Passive Bench Mount Device

2.7 FORCE DEVICE

During RemovalTool setup you must indicate what kind of device you are using. R[4:Force Device] is provided for this purpose. Type a value into R[4] based on the information in Table 2.7:

Table 2.7 Force Device Setup

Force Device	R[4] Value
Active Wrist	1
Passive Wrist	2
Passive Bench	3

Refer to the *OPERATOR'S MANUAL (Basic Function) (B-83284EN)* or the *HandlingTool Setup and Operations Manual (MAROUHT9307191E)* for more information on setting registers.

2.7.1 Passive Force Device Weight Compensation Program

You can adjust the `MR_WCOMP.PC` macro to different kinds of passive devices: AFD2000, AFD72 and AFD52. `MR_WCOMP.PC` (pc_equate) contains a force compensation routine that has variables you set for the particular model of the passive device.

The structure for the force compensation routine is shown in Figure 2.7.1.

```
TYPE
  mr_equate = STRUCTURE
    use_new_equ : BOOLEAN
    bias_voltage : REAL
    fp           : REAL
    vp           : INTEGER
    fn           : REAL
    vn           : INTEGER
    fnet         : REAL
    fp_pram1     : REAL
    fp_pram2     : REAL
    fn_pram1     : REAL
    fn_pram2     : REAL
  ENDSTRUCTURE

use_eq IN CMOS : pc_equate
```

Figure 2.7.1 MR_EQUATE Structure for Force Compensation Routine

Tool Weight Compensation program (MR_WCOMP.PC) uses its subroutine (MR_EQUATE.PC) for force compensation. MR_EQUATE.PC can be modified to fit specific models of force devices. This makes RemovalTool software flexible for passive devices.

You can modify FP_PRAM1, FP_PRAM2, FN_PRAM1, and FN_PRAM2 to accomplish this, where the letter p stands for positive force variables, and the letter n stands for negative force variables.

Refer to Section 2.7.1.1, Adjusting parameters in the MR_EQUATE.PC macro to adjust the parameters to adjust MR_EQUATE.PC to each type of device.

2.7.1.1 Adjusting parameters in the MR_EQUATE.PC macro

Procedure

1. Press **SELECT**.
2. Select the program MR_EQUATE and press **ENTER**.
3. Press **DATA** and press **F1, [TYPE]**.
4. Select **KAREL Vars**.

   NOTE

   You must have the KCL option loaded in order to access the KAREL variables.

   At initialization, the array shown in Figure 2.7.1 is set to zero, except for the following variables. The default values are shown in Table 2.7.1.1.

5. Change the fp_pram and pn_pram for each type of passive device accordingly. Refer to Table 2.7.1.1.

Table 2.7.1.1 Default Values for Passive Device Parameters

Passive Device	fp_pram1	fp_pram2	fn_pram1	fn_pram2
AFD2000 *	20.52	21.19	18.43	20.17
AFD72	18.27	0	18.27	0
AFD52	2.61	0	2.61	0
AFD-82	36.54	0	36.54	0
* The AFD2000 does not require an external electro-pneumatic regulator.				

NOTE

These settings are based on PushCorp's force device manuals and can only be used with the SMC ITV2050–11N3N4 external electro-pneumatic regulator.

2.7.2 ATI AOV-10 Setup

Procedure

1. Select the KAREL program `MREQUATE`.
   You should receive a message indicating that `MERQUATE` is selected.
2. Select **Data**.
3. Select **Type** > **KAREL Vars**.
   You should see the following screen:

Figure 2.7.2 (a) Data KAREL Vars

4. Select **Use AMP** and set to the values shown in Figure 2.7.2 (c) and Figure 2.7.2 (b).

5. Select **Use AMP2** and set to the values shown in Figure 2.7.2 (c) and Figure 2.7.2 (b).

Figure 2.7.2 (b) USE_AMP2 (A/O [2]

Figure 2.7.2 (c) USE_AMP (A/O [1])

2.8 TOOL WEIGHT

RemovalTool software needs the tool weight information to compensate for gravity and orientation changes from the nominal position.

If you have an active wrist mount device, you can use the `AUTOWGH` (Auto Weigh) macro to determine the weight of the end of arm tooling (EOAT). This value is stored in R[10] and is communicated to AFD by the set tool weight macro. `SET TOOL WEIGHT` macro is included at the beginning of any program as shown in Figure A.2.1.

If you have a passive wrist mount device, then you must manually determine the tool weight in pounds (lb.) and enter the weight into R[10]. Two decimal accuracy is sufficient. For example, R[10]=26.41 lb. You must include the following items in your tool weight calculation:

- Weight of the motor and clamps
- Weight of the tool medium
- Weight of the device carriage slide

Table 2.8 Device Weights

Model of Device	Carriage Weight = Wc (lbs)*
AFD-52/51	0.3

Model of Device	Carriage Weight = Wc (lbs)*
AFD-72/71	3.5
AFD-82/81	9
AOV-10	4

NOTE

1. The carriage weight is taken from the PushCorp manuals of corresponding devices.
2. Subject to change at OEM's discretion at any time.
3. The carriage weight needs to be added to the tooling weight which will be attached to the carriage.

After you have determined the weight, it must be entered into R[10:Tool Weight].

Refer to the *OPERATOR'S MANUAL (Basic Function) (B-83284EN)* or the *HandlingTool Setup and Operations Manual (MAROUHT9307191E)* for more information on setting up registers.

2.9 I/O SETUP

If you are using a wrist or bench type passive device, you need to connect the analog output AO 1 and 2 on the AFD2000 device cable as marked in PushCorp's AFD2000 force device manual. RemovalTool uses AO[1] and AO[2] to send voltages to the AFD device to set force specified in R[5: Programmed force]. A digital output (as specified in `STARTSP.TP`; `STOPSP.TP`) is typically used for turning the spindle or motor on and off.

If a device other than AFD2000 is used, then each analog output port needs to be connected to the corresponding external electro-pneumatic regulator (such as the SMC-ITV2050–11N3N4 series) to control the passive force device. (Examples of these commercially available devices are PushCorp's AFD72 and AFD52.) Refer to the electrical connections diagram in Figure 2.9 (c). For example, AO[1] is connected to the pneumatic servo value of the [+] positive direction value of the device, and AO[2] to the [-] negative direction value.

Refer to the *OPERATOR'S MANUAL (Basic Function) (B-83284EN)* or the *HandlingTool Setup and Operations Manual (MAROUHT9307191E)* for more information on setting registers.

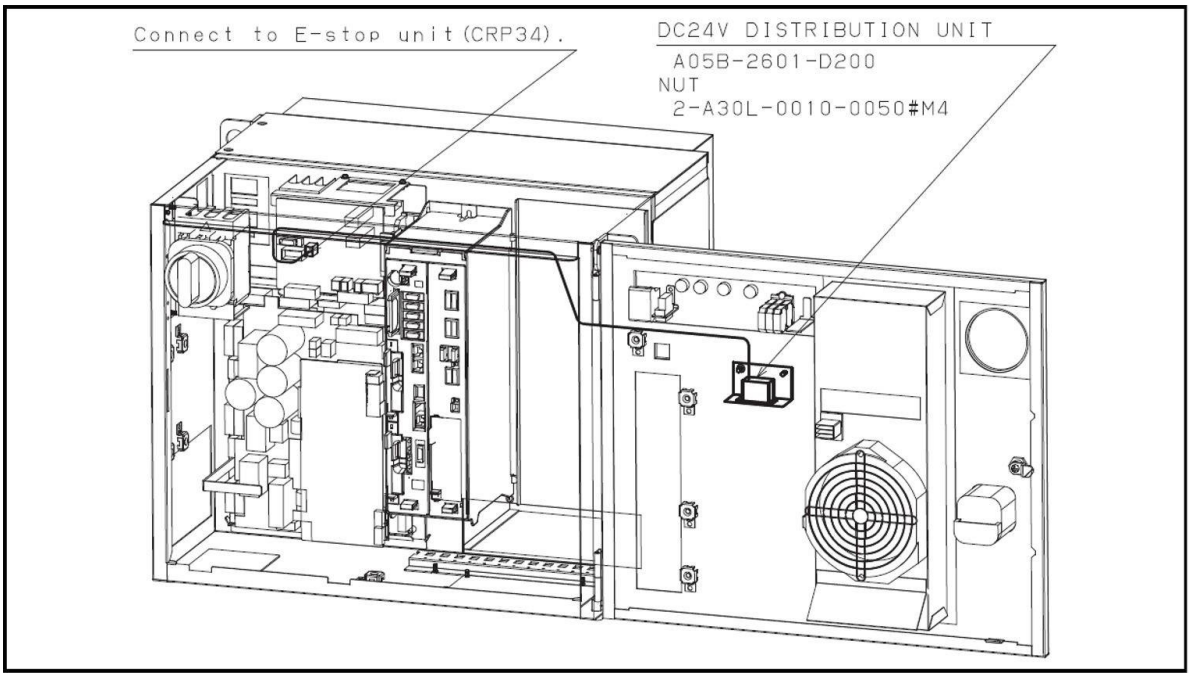

Figure 2.9 (a) 24V Distribution Cable

Part:	A05B-2601-D200 [CABLE WITH CONNECTOR]
L * W * H:	73.5 in * 3.13 in * 1.47 in
Weight:	0.4 lb

Figure 2.9 (b) Power Cable Details

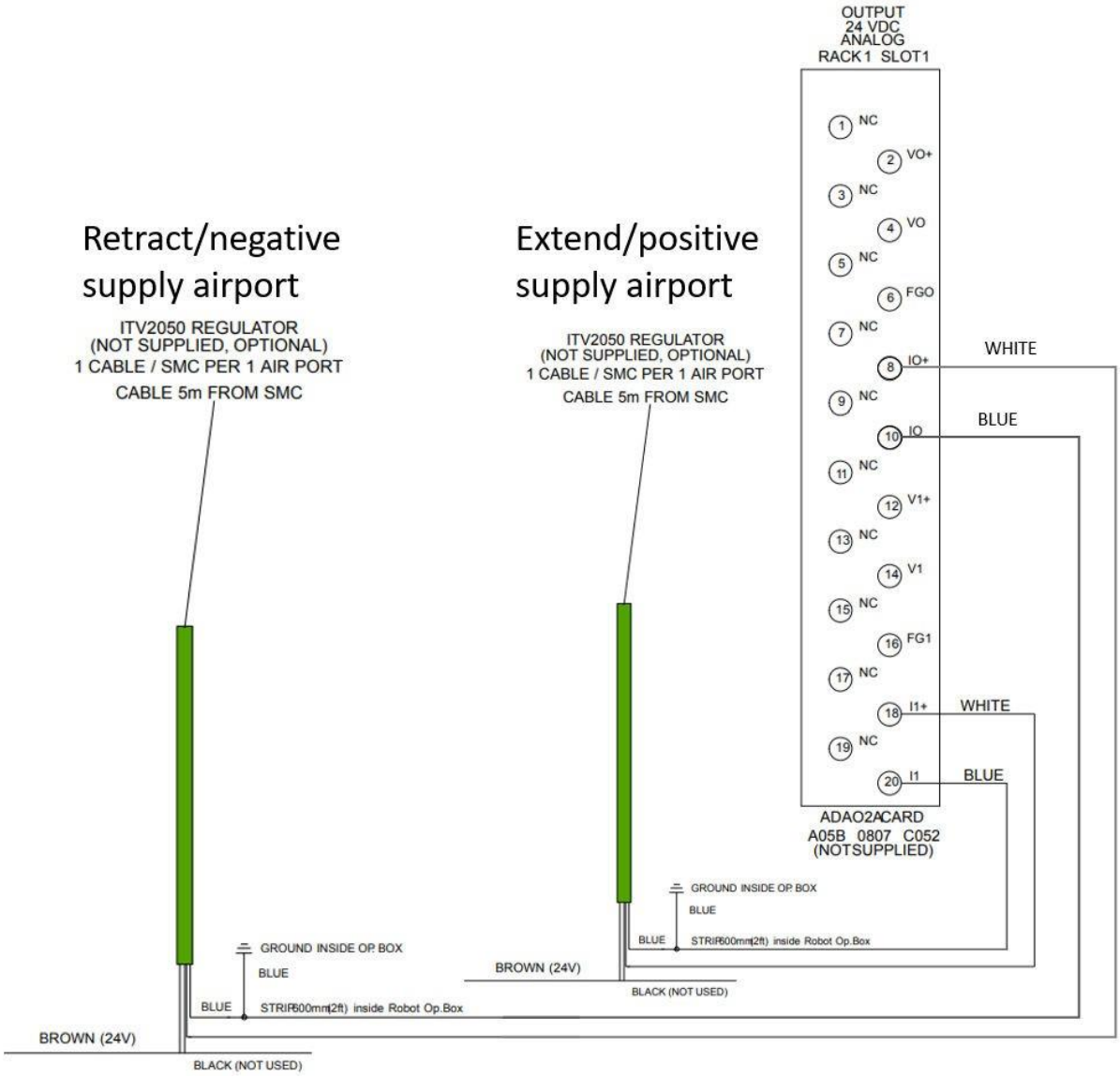

Figure 2.9 (c) I/O Connections

3 PROGRAMMING

3.1 WRITING A PROGRAM

You can either use a RemovalTool template program or write your own.

3.1.1 Using A RemovalTool Template Program

If you are modifying a RemovalTool template teach pendant program, the order in which the macros should be called is identified in the template program. Refer to Appendix A, REMOVALTOOL PROGRAMS for the template program specific to the kind of device you are using. Use Section 3.1.1.1, How to use a RemovalTool template program to use a RemovalTool template program.

3.1.1.1 How to use a RemovalTool template program

Procedure

1. Press **SELECT**.
2. Press **F1, [TYPE]**.
3. Select **TP programs**.
4. Choose the teach pendant template program appropriate for your force control device:
   - `ACTVWTMP` - For use with the Active Wrist Force Control Device.
   - `PASSWTMP` - For use with the Passive Wrist Force Control Device.

     NOTE

     If you want to use the wrist compensation program, the program must start with Run `MRWCOMP`. See below.

     ```
     Run MRWCOMP LBL[X] Programming JMP LBL[X]
     ```

   - `PASSBTMP` - For use with the Passive Bench Device.
5. Copy the template teach pendant program you have chosen into your own teach pendant program.

   Refer to the *OPERATOR'S MANUAL (Basic Function) (B-83284EN)* or the *HandlingTool Setup and Operations Manual (MAROUHT9307191E)*.

What to do next

You can now modify the copied template program as desired.

3.1.2 Writing Your Own RemovalTool Program

If you are writing your own RemovalTool teach pendant program, you must set up the macros in the correct order. Refer to the template program specific to your force control device (Appendix A, REMOVALTOOL PROGRAMS), for the correct macro order.

Refer to Chapter 2, SETTING UP REMOVALTOOL for information on how to set up a RemovalTool application before you actually begin writing the program.

For more information on how to write a teach pendant program, refer to the *OPERATOR'S MANUAL (Basic Function) (B-83284EN)* or the *Planning and Creating a Program* chapter in the *HandlingTool Setup and Operations Manual (MAROUHT9307191E)*.

3.1.3 Using RemovalTool Macros

A macro command program is a separate program that contains a series of instructions to perform a task.

This section contains a listing of the standard macros that are included with RemovalTool. It also contains a listing of the teach pendant program that stands behind each RemovalTool macro. Think of a macro as a call name for each corresponding teach pendant program.

For more information on how to use macros, refer to the *OPERATOR'S MANUAL (Basic Function) (B-83284EN)* or the *General Setup* chapter in the *HandlingTool Setup and Operations Manual (MAROUHT9307191E)*.

Macro Table

Table 3.1.3 provides detailed information about each RemovalTool macro.

NOTE

Active refers to AFD1000 and Passive refers to AFD2000 for `ADJUST TOOL` and `ADJUST UFRAME` only. AFD72 and AFD52 do not have positioned feedback and cannot be used with `ADJUST TOOL` and `ADJUST UFRAME`. Active/Passive can be used with all device types.

Table 3.1.3 RemovalTool Macros

Instruction Name	Program Name	Device Used In	Condition/Actions
ACTIVE SLIDE POS	SLIDEPOS.MR	Active Wrist/Bench	Retrieves the slide position from the AFD controller to the robot. This value is set in data register R[16].
ADJUST TOOL WT	MRWCOMP.MR	Passive Wrist	Uses the tool weight and force entered on the RT Data SETUP screen, to adjust for forces at different tool orientations. Continuously updates AO[1] and AO[2] based on the tool orientation.

Instruction Name	Program Name	Device Used In	Condition/Actions
ADJUST UFRAME	ADJUFRAM.MR	Active (AFD1000) and Passive (AFD2000) Bench	Starts the wheel wear search and shifts the USER frame by the offset found. This macro should be inserted into your teach pendant program after the search start position is taught.
ADJUST UTOOL	ADJUTOOL.MR	Active Wrist	Starts the wheel wear search and applies the offset to UTOOL[1] which is based on PR[1] (Nominal UTOOL). The ADJUSTUTOOL macro should be inserted into your teach pendant program after the search start position is taught.
MOVE TO PERCH	PRGPERCH.MR	No Device Dependence	Moves the robot to the perch position. Should be set only one time for each robot system. Value is stored in PR[10].
SET AFD FORCE	CMDFORCE.MR	Active Wrist	Sends the force entered on the RTData SETUP menu to the AFD controller. This value is set in data register R[5].
STOP ACTIVE DEV	STOPAFD.MR	Active Wrist	Terminates communication with the AFD controller.
AUTO WEIGH EOAT	AUTOWGH.MR	Active Wrist	Instructs the AFD to weigh the tool.
SET TOOL WEIGHT	SETTOOLW.MR	Active Wrist	Uses the tool weight to adjust for forces at different tool orientations. Tool weight is set in data register R[10].
START ACTIVE DEV	STARTAFD.MR	Active Wrist/Bench	Initiates communication with the AFD controller.
START SPINDLE	STARTSP.MR	Active, Passive, Wrist/Bench	Turns on the spindle. The output can be changed to either a robot digital output (RDO) or a digital output (DO). The status of ON (1) or OFF (0) is contained in data register R[1]. See Section 3.1.3, STARTSP.MR .

Instruction Name	Program Name	Device Used In	Condition/Actions
STOP SPINDLE	STOPSP.MR	Active, Passive, Wrist/Bench	Turns off the spindle. The output can be changed to either a robot digital output (RDO) or a digital output (DO). The status of ON (1) or OFF (0) is contained in data register R[1]. See Section 3.1.3, STOPSP.MR .

> ⚠ **CAUTION**
>
> Do not use a macro which is not designed for your force control device. Otherwise you could damage equipment.

Macro Programs

This section contains each RemovalTool macro program.

ACTIVE SLIDE POS

The corresponding program name for this macro is `SLIDEPOS.MR`.

The corresponding program name for this macro is `CMDFORCE.MR`.

CMDFORCE.MR

```
1:  CALL CMD_FORC ;
/POS
/END
```

SLIDEPOS.MR

```
1:  CALL GETSLPOS ;
/POS
/END
```

ADJUST TOOL WT

The corresponding program name for this macro is `MRWCOMP.MR`. `MRWCOMP.MR` should run once before starting production. This program will run in the background to provide passive device tool weight and gravity compensation. Pressing **FCTN** and **ABORT ALL** will abort `MRWCOMP.MR`.

MRWCOMP.MR

```
1:  RUN MR_WCOMP ;
/POS
/END
```

ADJUST UFRAME

The corresponding program name for this macro is `ADJUFRAM.MR`.

ADJUFRAM.MR

```
1:  IF R[4]=2,JMP LBL[100] ;
   2:  PR[8]=PR[7]    ;
   3:  PR[3]=LPOS    ;
   4:  R[20]=0    ;
   5:  LBL[10:SENSOR SEARCH] ;
   6:  R[20]=R[20]+1    ;
   7:  PR[8]=PR[8]+PR[2]    ;
   8:  UFRAME[1]=PR[8] ;
   9:L PR[3] 100mm/sec CNT10    ;
  10:  ACTIVE SLIDE POS    ;
  11:  IF R[16]<.6,JMP LBL[20] ;
  12:  JMP LBL[30] ;
  13: LBL[20:Retract to START] ;
  14:  UFRAME[1]=PR[7] ;
  15:L PR[3] 200mm/sec CNT10    ;
  16:  UFRAME[1]=PR[8] ;
  17:  JMP LBL[100] ;
```

ADJUST UTOOL

The corresponding program name for this macro is ADJUTOOL.MR.

ADJUTOOL.MR

```
1:  IF R[4]=3,JMP LBL[100] ;
   2:  PR[4]=PR[1]    ;
   3:  PR[3]=LPOS    ;
   4:  R[20]=0    ;
   5:  LBL[10:SENSOR SEARCH] ;
   6:  R[20]=R[20]+1    ;
   7:  PR[4]=PR[4]+PR[2]    ;
   8:  UTOOL[1]=PR[4] ;
   9:L PR[3] 100mm/sec CNT10    ;
  10:  ACTIVE SLIDE POS    ;
  11:  IF R[16]<.6,JMP LBL[20] ;
  12:  JMP LBL[30] ;
  13: LBL[20:Retract to START] ;
  14:  UTOOL[1]=PR[1] ;
  15:L PR[3] 200mm/sec CNT10    ;
  16:  UTOOL[1]=PR[4] ;
  17:  JMP LBL[100] ;
  18: LBL[50:Sensor Alarm] ;
  19:  UALM[1] ;
  20:  PAUSE ;
  21:  ABORT ;
  22:  JMP LBL[100] ;
  23: LBL[30:Check Srch Range] ;
  24:  IF R[20]=20,JMP LBL[50] ;
  25:  JMP LBL[10] ;
  26:  LBL[100:End of Program] ;
```

DEFAULT DELAY

The corresponding program name for this macro is MRWAIT.MR.

MRWAIT.MR

```
1:  CALL MRWAIT ;
/POS
/END
```

MOVE TO PERCH

The corresponding program name for this macro is PRGPERCH.MR.

PRGPERCH.MR

```
1:  J PR[10] 25% FINE    ;
/POS
/END
```

SET TOOL WEIGHT

The corresponding program name for this macro is SETTOOLW.MR.

SETTOOLW.MR

```
1:  CALL SET_TOOL ;
/POS
/END
```

START ACTIVE DEV

The corresponding program name for this macro is STARTAFD.MR.

STARTAFD.MR

```
1:  CALL STRT_AFD ;
/POS
/END
```

START SPINDLE

The corresponding program name for this macro is STARTSP.MR.

STARTSP.MR

```
1:  IF R[25]=0,JMP LBL[11] ;
   2:  RO[1]=ON ;
   3:  WAIT    .50(sec) ;
   4:  R[25]=0    ;
   5:  LBL[11] ;
   6:  R[1]=1    ;
```

STOP SPINDLE

The corresponding program name for this macro is STOPSP.MR.

STOPSP.MR

```
1:  DO[1]=OFF ;
2:  R[1]=0 ;
```

```
/POS
/END
```

3.1.4 Adjust UTOOL Or UFRAME

After the search start position is taught, the ADJUST UTOOL or ADJUST UFRAME macro must be inserted in the teach pendant program. Whether you insert ADJUST UTOOL or ADJUST UFRAME depends on the kind of force control device you are using. Refer to Table 3.1.3 if you do not know which one to use.

3.2 FORCE, TOOL WEAR, AND WHEEL WEIGHT COMPENSATION

The RemovalTool software is designed to compensate for certain inevitable situations that will arise when you run a removal operation.

3.2.1 Setting Forces

The command force in an application is specified for the nominal orientation of the tool. In order to maintain the specified force between contact points, the force value must be modified at tool orientations other than the nominal orientation.

After the command force is set, the RemovalTool software automatically takes into account the tool weight and tool orientation and maintains the command force within a specified tolerance.

There should only be minor fluctuations in this value as stated in the datasheet. The number should remain relatively stable, regardless of the slide position or device orientation.

If you are using the active wrist force control device in your program, set R[5:Programmed Forces]=value and then call the SET AFD FORCE macro. This macro communicates the value in R[5] to the force controller.

If you are using the passive wrist force control device, do the following:

1. Set up the electrical and pneumatic connection as described in Chapter 2, SETTING UP REMOVALTOOL for the dual acting passive device.
2. Configure RemovalTool software for the kind of passive device you have:
   a. Set FP_PARAM and FN_PARAM as described in Section 2.7.1, Passive Force Device Weight Compensation Program.
   b. Set registers R[4], R[5], R[10], and R[15] as described in Section B.1, REGISTER ASSIGNMENTS. Refer to Table B.1.
3. Run MRWCOMP.MR program once to initiate tool weight compensation. Then change R[5:FORCE]=value as the process requires.

The force value will be applied automatically into the passive device as MR_WCOMP tool weight compensation program is running in the background. Therefore, you can change force values in the production program and the RemovalTool macro will automatically update the applied force.

NOTE

To stop tool weight compensation, press **FCTN** and select **ABORT ALL**. This will stop `MR_WCOMP` macro from running in the background.

3.2.2 Tool Wear Compensation

Tool wear applies only to soft media such as sand disk, grinding wheels, and scotch brite wheels.

Tool wear compensation applies to all tools: active wrist, passive wrist, and passive bench mount. As the tool (abrasive wheel diameter for example) wears out, FANUC recommends that you detect it at the start of the operation by using the `ADJUST UTOOL` (for wrist mount) or `ADJUST UFRAME` (for bench mount) devices. This modifies the Tool Frame by the tool wear amount. Taught robot positions are not modified by the software.

The overall process cycle time can be reduced significantly, if the amount of tool wear is measured accurately and the tool frame is modified accordingly.

You must also teach a search start position right before calling the `ADJUST UTOOL` or `ADJUST UFRAME` macro. During operation, the robot will move to this search start position and then move by a distance of -2 mm along the user selected slide direction, until either the stroke sensor goes from ON to OFF (as in the case of the passive wrist device) or the slide direction is at 0.4 inches (as in the case of the active wrist device) after contact is made.

When the bench mounted device is used, the User Frame is shifted along the selected slide direction until the stroke sensor goes from ON to OFF (as in the case of the passive wrist device) or the slide direction is at 0.4 inches (as in the case of the active wrist device) after contact is made. The modified User Frame is used to compensate for wheel wear and maintain the slide at its mid stroke position.

Refer to Section 2.6, SEARCH DISTANCE AND DIRECTION FOR WHEEL WEAR for more information about searching distance and direction for wheel wear.

3.2.3 Wheel Weight Compensation

Wheel weight compensation can be used with active wrist only. Wheel weight compensation can be used only with sanding or grinding media that loses its weight due to process.

If you have an active wrist force control device, wheel weight can be automatically determined by the AFD controller using the Autoweigh EOAT macro.

If you have a passive wrist force control device, no force feedback is available. `ADJUST TOOL WT` macro should be used to apply the programmed force, based on tool orientation and tool weight. The macro uses the setup information to estimate the tool weight based on the amount of tool wear, and provide the required compensation.

4 TESTING A PROGRAM AND RUNNING PRODUCTION

4.1 TESTING A REMOVALTOOL PROGRAM

Test run RemovalTool after you have completed all setup. Refer to Chapter 2, SETTING UP REMOVALTOOL for setup information.

After you test run for the first time you might need to adjust the path or other setup data and test again. Refer to Section 4.2, PERFORMANCE FACTORS AND GUIDELINES for some tips and guidelines about RemovalTool performance.

4.1.1 Testing A Program

Use Section 4.1.1.1, Testing a RemovalTool program to test a RemovalTool program.

Messages will be listed on the screen.

4.1.1.1 Testing a RemovalTool program

Before you begin

- The force control device has been installed. Refer to Chapter 2, SETTING UP REMOVALTOOL.
- All personnel and unnecessary equipment are out of the workcell.

Procedure

1. To teach a perch position,
   a) Press **SELECT**.
   b) Press **F1, [TYPE]**.
   c) Select **Macro**.
   d) Select `PRGPERCH` and press **ENTER**. You will see a screen similar to the following.

```
1/2
1 :  J PR[10] 5% FINE
  [End]
```

   e) Jog the robot to a perch position above the height of the highest part.

2. To record a position, press **SHIFT** and **F4, TOUCHUP**.

> **NOTE**
>
> You can teach only one perch position per robot system. Make sure you teach the perch position so that it will accommodate any operation you might run in that workcell. After the perch position is taught it does not have to be re-taught.

3. Check the air supply and test the tool device before you test run the RemovalTool application.
   a) Verify that the air supply is adequate by looking at the gauge.

      For both active and passive wrist force control devices, the air supply should be maintained at 100 psi (pounds per square inch).

4. To test run the application
   a) Set the REMOTE/LOCAL setup item in the System Configuration Menu to LOCAL.
   b) Set the jog speed to 25% or less.
   c) Select the template program you want to use from the SELECT menu.
   d) Move the robot to the perch position using the `PRGPERCH` macro program.
   e) Press the **CYCLE START** button on the controller to start the application program.

      The robot will move to the search start position and use the `Adjust Utool` macro to check for wheel wear.

      The application program will automatically begin running.
   f) Press the Display Status key on the Teach Pendant.

5. If you want to track the activity of the controller,
   a) Press **MENU**.
   b) Select **ALARM**.
   c) Press **F1, [TYPE]**.
   d) Select **Appl Log**.

4.1.2 Monitoring Teach Pendant Programs

You can monitor a running teach pendant program from the SELECT menu. When you monitor a running program, the program is displayed and the cursor highlights the line currently being executed.

Use Section 4.1.2.1, Monitoring a running teach pendant program to monitor a running teach pendant program.

4.1.2.1 Monitoring a running teach pendant program

Before you begin

The teach pendant program(s) you want to monitor is (are) currently executing.

Procedure

1. Press **SELECT**.

```
Select
                      50983 BYTES FREE
No.  Program name                  Comment
 1   SUB1                       PR[            ]
 2   MAIN25                     JB[            ]
 3   PRG7                       MR[            ]
```

2. Press **F4, MONITOR**.

The program will be displayed on the screen.

If more than one program is running, you will see a screen similar to the following. The cursor will be on the line number of the instruction that is currently being executed. The cursor will move to each instruction as it is executed.

```
LONGDELAYPROGRA>  LINE 1    AUTO RUNNING\\\\\\\\\\\JOINT\100\
%
Select\(monitor)\\\\\\\\\\\\\\\\
\
             TASK
STATUS
\1\EXEC1\\\\LONGDEL>\[LONGDEL>:Running
\]
 2 EXEC2    DELAY1
[DELAY1  :Running ]
 3 EXEC3    DELAY2
[DELAY2  :Running ]









Select monitor
program
 PROG   ROUT      PAUSE   ABORT
```

If the program or task name is longer than 8 characters, the full name will be displayed on the prompt line. The PROG and TASK keys designate which name is displayed on the prompt line. See the following screen for an example.

```
LONGDELAYPROGRA>  LINE 1    AUTO RUNNING\\\\\\\\\\\JOINT\100\
%
Select\(monitor)\\\\\\\\\\\\\\\\
\
             TASK
STATUS
\1\EXEC1\\\\LONGDEL>\[LONGDEL>:Running
\]
 2 EXEC2    DELAY1
[DELAY1  :Running ]
 3 EXEC3    DELAY2
[DELAY2  :Running ]
```

```
LONGDELAYPROGRAMNAME

 PROG   ROUT      PAUSE
ABORT
```

3. To look at another area of the program while the program is being displayed, press **F2, LOOK**. When you want the cursor to return to the line number of the instruction currently being executed, press **F2, MONITOR**.

4.2 PERFORMANCE FACTORS AND GUIDELINES

The process performance of any RemovalTool application depends on many factors including tool orientation, robot speed, spindle speed, abrasive media, and path profile.

As the user, you should be aware that you have control over these factors, and thus the performance of your application. This section contains some tips and guidelines that might help you to improve the performance of your application.

4.2.1 Tool Orientation

Make sure the wheel is perpendicular to the contact surface when your application uses an abrasive wheel.

If your application uses an abrasive disc, the tool should be rotated, such that only the outer edge of the disc makes contact with the part surface. Otherwise, the abrasive plate can get damaged easily.

Keep in mind that the command force is the force applied along the direction of the slide. If this slide is not perpendicular to the contact surface, only one component (along the direction of the slide) of the actual applied force is equal to the command force.

It is highly recommended that you use the 6-point method of teaching the UTOOL. In order for the wrist-mounted force device to operate properly, the positive slide direction must be along the -x direction of the UTOOL.

4.2.2 Robot Speed

Robot speed depends mainly on the abrasive media, spindle speed, and part surface. However, speeds above 150 mm/sec are not recommended. They might cause the weight compensation to be ineffective. When you test run your application or run production, FANUC recommends always setting the override to 100.

4.2.3 Spindle Speed

FANUC currently offers spindles that have only one speed. However, the RemovalTool software has the capability to implement multiple speed spindles. This requires appropriate I/O wiring and additional programming within the user application program. Contact FANUC before using spindles with multiple speeds or any other custom spindles.

4.2.4 Tool Media

RemovalTool software handles only wheel, cup, and disc media. However, it is possible to implement other tool media in RemovalTool. Contact FANUC before you use any other tool media.

4.2.5 Path Teaching Guidelines

The way in which you teach the robot positions has a considerable impact on the process performance. Make sure that the contact time between part surface and tool media is kept consistent throughout the robot path. This ensures that the removal process is consistent.

Since the tool is expected to operate at its mid-stroke, the positions at the beginning of the path must be slightly away from the part surface and gradually touch the surface along its path. Similarly, the robot must retract away gradually to make sure that the contact time of the tool with the part surface is consistent. Otherwise more material might be removed at the start and end point of the robot path.

It is also important that the tool orientation is changed gradually whenever possible. This allows the robot to compensate effectively for the tool weight and maintain the command force at the contact point. This might not be possible while moving the tool around sharp corners. However, you can slow down the robot speed and reduce the spindle speed to get better results. Circular motion type is recommended at corner positions.

4.2.6 E-Stop Or Pause

RemovalTool retracts the tool automatically and stops the spindle from spinning whenever the robot is in an EMERGENCY STOP or PAUSE condition. This separates the tool from the work piece and protects both the tool and the part. This is achieved from the ESTOP-CH program.

4.3 EXECUTING MACRO COMMANDS

Refer to the Section 1.1.2, Programming for information on RemovalTool macros. Refer to the *OPERATOR'S MANUAL (Basic Function) (B-83284EN)* or the *HandlingTool Setup and Operations Manual (MAROUHT9307191E)* for information on setting up and executing macros and on the macro command program instruction.

4.4 PRODUCTION OPERATION

Refer to the *OPERATOR'S MANUAL (Basic Function) (B-83284EN)* or the *HandlingTool Setup and Operations Manual (MAROUHT9307191E)* for more information on production operation setup and execution.

5 ERROR CODES AND TROUBLESHOOTING

5.1 ERROR CODES

Error codes appear on the alarm log.

Refer to the *Alarm Code List (B-83284EN-1)* or the *Error Code Manual (MARRUEROR02171E)* for a complete listing of error codes.

5.2 TROUBLESHOOTING

This section contains information that will help you solve problems you might have while running RemovalTool.

Table 5.2 includes common symptoms and possible solutions to the problems.

Table 5.2 Troubleshooting Symptoms and Solutions

Symptom	Possible Cause	Possible Solution
The force control device is searching in the wrong direction.	The UFRAME or UTOOL is set incorrectly.	Re-teach the UFRAME with the three point method, or the UTOOL with the six point method by following the procedures in the application-specific *Setup and Operations Manual* or the OPERATOR'S MANUAL (Basic Function) (B-83284EN).
The slide does not go to mid stroke during the application.	The UTOOL might not be adjusted properly.	Make sure the Adjust Utool macro has been inserted in the proper place in the user teach pendant program.
The tool does not extend.	The proper force is not being applied.	For the active force device, make sure the tool weight is set properly, the communication cable is connected, the AFD communication LED is flashing, the air hose is connected and the air pressure is being maintained at 80 to 100 psi. For the passive device, make sure the air pressure is at least 60 psi.
The search ends up in an alarm or error condition.	The search range set in the ADJUTOOL teach pendant program might have been exceeded.	Teach the search start position so that it is just touching the part surface and the tool is fully extended.

Symptom	Possible Cause	Possible Solution
The robot does not seem to move along the taught path.	The proper UTOOL or UFRAME was not set on the RT Data screen.	Make sure the program has the proper UTOOL or UFRAME.
The robot does not search in the proper direction while running Adjust Utool.	UTOOL or UFRAME was taught incorrectly.	Make sure UTOOL is correct by jogging in the Tool Coordinate Frame.
	The *slide direction* is incorrect.	Check the slide direction.
Spindle does not turn ON or OFF.	The `Start Spindle`/`Stop Spindle` macros are not used in the TP program.	Compare your Teach Pendant program with the corresponding template program to make sure you are using the correct macro.
	The specified I/O for spindle ON/OFF in incorrect.	Make sure the I/O spindle ON and OFF macros are set up correctly.
	The spindle does not have air or power.	Check the power and air supply. This can be done manually by turning on the appropriate I/O to start the spindle.
Spindle turns on too late.	The spindle needs some time to reach its r.p.m.	Turn on the spindle before the last approach point.
Spindle stalls.	Too much force is being used.	Decrease the amount of force used.
Slide does not engage.	The slide does not have air.	Make sure the slide is receiving air.
	Active Force Device controller communication is not met (active device only).	Make sure the AFD communication line in the controller is working properly. If it is, the communication light on the AFD controller will be flashing.

Symptom	Possible Cause	Possible Solution
The force device does not apply the correct force to the part.	The proper *force* was not specified.	Make sure the desired force has been set correctly.
	The proper *tool weight* was not specified.	Make sure the tool weight has been set correctly. For the AFD, the autoweight function can be used.
	For the passive device, the standard *scale factor* might have changed.	Check R[21] to see if the pneumatic standard scale factor is = 75. Make sure the control valves are functioning properly.
	For the active device, the AFD controller communication is not working.	Clear the communication port for the AFD controller.
	The `SET AFD FORCE` and/or `SET TOOL WT` macro(s) are not being used.	Make sure the SET AFD FORCE macro has been inserted in your teach pendant program at the correct location. Refer to the `ACTVTEMP.TP` program in Appendix A, REMOVALTOOL PROGRAMS.
Robot takes off more material at the beginning and end of the part.	The *approach points* to the part might be too steep.	Make sure the approach points achieve the desired motions.
Robot takes off too much material.	The applied force is too high.	Lower the applied force.
	The robot speed is too slow.	Increase the robot speed.
	The spindle speed is too fast (for variable speed spindles only).	Decrease the spindle speed.
	The media being used is incorrect for the application.	Make sure the proper media is being used.
`Robot is not at perch` message is given at the start of the cycle, even though the robot seems to be at the perch position.	The perch position was not taught with the nominal UTOOL.	Re-teach the perch position using the nominal UTOOL.

APPENDIX

A REMOVALTOOL PROGRAMS

A.1 MR TEACH PROGRAM

The MR TEACH program is responsible for extending the active wrist, passive wrist, or bench mounted slide. It also sets the values of certain registers and analog outputs, and initiates certain RemovalTool macros.

```
 1:  IF R[4]=1, JMP LBL[10] ;
 2:  IF R[4]=2, JMP LBL[20] ;
 3: !Passive Bench Device ;
 4:  R[6]=R[5]*R[21] ;
 5:  AO[1]=R[6] ;
 6:  JMP LBL[100] ;
 7:  ;
 8: LBL[10:Active Wrist] ;
 9:  START ACTIVE DEV ;
10:  SET AFD FORCE ;
11:  JMP LBL[100] ;
12:  ;
13:  LBL[20:Passive Wrist]
```

A.2 TEMPLATE PROGRAMS

The following template programs can be used as they are, or modified to fit your specific removal application needs.

There are three template programs included in this section. Use the program that corresponds to the force control device type you have.

- If you have an active wrist force control device, use the program in Section A.2.1, Active Wrist Force Control Device
- If you have a passive wrist force control device, use the program in Section A.2.2, Passive Wrist Force Control Device
- If you have a passive bench mounted device, use the program in Section A.2.3, Passive Bench Mount Force Control Device

A.2.1 Active Wrist Force Control Device

The following template program should be used if you have an active wrist force control device mounted on your robot.

```
1:  !****************************** ;
2:  !* TEMPLATE PROGRAM FOR ACTIVE * ;
3:  !* FORCE DEVICE.              * ;
4:  !****************************** ;
5:  MOVE TO PERCH    ;
6:  START ACTIVE DEV    ;
7:  !Tool Weight ;
```

```
8:  AUTO WEIGH EOAT    ;
9: !SET Command force (lb)in R[5] ;
10:  R[5]=5  ;
11:  SET AFD FORCE    ;
12:  ;
13:  !****************************** ;
14:   !*Teach Search Start Pos.     * ;
15:  !****************************** ;
16:  ;
17:  L P[1] 100mm/sec CNT10    ;
18:  ADJUST UTOOL    ;
19:  ;
20:  LBL[10:START] ;
21:  ;
22:  !****************************** ;
23:   !*Teach Approach Positions    * ;
24:  !****************************** ;
25:  ;
26:  L P[2] 100mm/sec CNT100    ;
27:  L P[3] 100mm/sec CNT10    ;
28:  ;
29:  START SPINDLE    ;
30:  ;
31:  !****************************** ;
32:   !*Teach part Positions.       * ;
33:  !****************************** ;
34:  ;
35:  !****************************** ;
36:  !*Teach Departure Positions.   * ;
37:  !****************************** ;
38:  ;
39:  STOP SPINDLE    ;
40:  MOVE TO PERCH    ;
41:  STOP ACTIVE DEV    ;
42:  ;
43:  END ;
```

Figure A.2.1 Active Wrist Template Program

A.2.2 Passive Wrist Force Control Device

The following template program should be used if you have a passive wrist force control device mounted on your robot.

```
1:  !****************************** ;
2:  !* TEMPLATE PROGRAM FOR PASSIVE* ;
3:  !* WRIST FORCE DEVICE.         * ;
4:  !****************************** ;
5:   ;
6:  !****************************** ;
7:   !*Teach Perch @ PR(10)        * ;
8:  !****************************** ;
9:  MOVE TO PERCH    ;
10:  ADJUST TOOL WT    ;
11:   ;
12:  !****************************** ;
13:   !Teach Search Start Pos.      * ;
14:  !****************************** ;
```

```
15:L P[1] 100mm/sec FINE    ;
16:   ;
17:  ADJUST UTOOL    ;
18:   ;
19:  LBL[10:START] ;
20:   ;
21:  !****************************** ;
22:   !*Teach Approach Positions    * ;
23:  !****************************** ;
24:J P[2] 100% CNT20    ;
25:J P[3] 50% CNT20    ;
26:  START SPINDLE    ;
27:J P[4] 50% CNT20    ;
28:   ;
29:  !****************************** ;
30:   !*Teach part Positions.       * ;
31:  !****************************** ;
32:L P[5] 100mm/sec CNT100    ;
33:L P[6] 100mm/sec CNT100    ;
34:   ;
35:  !****************************** ;
36:  !*Teach Departure Positions.   * ;
37:  !****************************** ;
38:L P[7] 250mm/sec CNT100    ;
39:J P[8] 100% CNT50    ;
40:   ;
41:  MOVE TO PERCH    ;
42:  STOP SPINDLE    ;
43:   ;
44:  END ;
```

Figure A.2.2 Passive Wrist Template Program

A.2.3 Passive Bench Mount Force Control Device

The following template program should be used if you have a passive bench mount force control device mounted on your robot.

```
1:  !****************************** ;
2:  !* TEMPLATE PROGRAM FOR PASSIVE* ;
3:  !* BENCH DEVICE.                * ;
4:  !****************************** ;
5:   ;
6:  !****************************** ;
7:   !*Teach Perch @ PR(10)         * ;
8:  !****************************** ;
9:  MOVE TO PERCH    ;
10:   ;
11: !Set command force via ;
12:  !AO[1] : extend ;
13: !AO[2] : retract ;
14:   ;
15:  !****************************** ;
16:   !Teach Search Start Pos.      * ;
17:  !THIS POSITION MUST BE         * ;
18:  !PERPENDICULAR TO THE CENTER   * ;
19:  !OF THE WHEEL. ;
20:  !****************************** ;
```

```
21:L P[1] 100mm/sec FINE    ;
22:   ;
23:  ADJUST UFRAME    ;
24:   ;
25:  LBL[10:START] ;
26:   ;
27:  !****************************  ;
28:   !*Teach Approach Positions    * ;
29:  !**************************** ;
30:J P[2] 100% CNT20    ;
31:J P[3] 50% CNT20    ;
32:  START SPINDLE    ;
33:L P[4] 100mm/sec CNT100    ;
34:   ;
35:  !****************************  ;
36:   !*Teach part Positions.       * ;
37:  !**************************** ;
38:   ;
39:L P[5] 100mm/sec CNT100    ;
40:L P[6] 100mm/sec CNT100    ;
41:   ;
42:  !****************************  ;
43:  !*Teach Departure Positions.   * ;
44:  !**************************** ;
45:L P[7] 250mm/sec CNT100    ;
46:J P[8] 100% CNT50    ;
47:   ;
48:  MOVE TO PERCH    ;
49:  STOP SPINDLE    ;
50:   ;
51:  END ;
```

Figure A.2.3 Passive Bench Mount Template Program

B REMOVALTOOL DATA

B.1 REGISTER ASSIGNMENTS

This section includes register assignments for RemovalTool.

Refer to Table B.1 for RemovalTool Data Register Assignments.

Table B.1 Data Register Assignments

Instruction	Description
R[1:Spindle status]	Reserved for FANUC.
R[2:Product-id]	Reserved for FANUC.
R[3:Reserved]	Reserved for FANUC.
R[4:Force Device]	The type of force control device or wrist attached to your robot. 1=Active Wrist 2=Passive Wrist 3=Passive Bench Mount
R[5:Programmed force (lb)]	The amount of force to be applied in pound force. [lbf] Conversion metric ⇒ English: X[lbf] = F[N] / 4.5
R[6:Slide Dir Comp]	The positive slide direction of the wrist mounted force device. 0=Slide in -x direction 1=Slide in +z direction
R[7: Reverse Force]	Reserved for FANUC.
R[8:Tool medium]	Reserved for FANUC.
R[9:Wheel radius]	Reserved for FANUC.
R[10:Tool weight]	The weight of the tool (in pounds). This includes the motor, tool media, slide, and any other device used to mount the tool to the force control device.
R[11:Spindle speed]	Reserved for FANUC.
R[12: Robot pos source]	Reserved for FANUC.
R[13:]	Reserved for FANUC.
R[14:]	Reserved for FANUC.

Instruction	Description
R[15:Slide direction]	The direction that the tool slides. This information is used during production to adjust the Tool Frame and weight compensation. = 1 if the slide is along the UTOOL +x direction = 2 if the slide is along the UTOOL +y direction = 3if the slide is along the UTOOL +z direction
R[16:AFD Slide Pos]	Reserved for FANUC.
R[17:]	
R[18:Reg_DELAY]	Reserved for FANUC.
R[19:]	
R[20:Search Cycle Cnt]	This register contains the number of search attempts after running the `ADJUST UTOOL` or `ADJUST UFRAME` macros.
R[21:Scale Factor]	Reserved for FANUC.
R[22:AFD Error Number]	This register contains the identification number of the error received.
R[23:]	Reserved for FANUC.
R[24:]	Reserved for FANUC.
R[25:]	Reserved for FANUC.
R[26:]	Reserved for FANUC.
R[27:]	Reserved for FANUC.
R[28:]	Reserved for FANUC.
R[29: Compensation Amt]	Reserved for FANUC.
R[30:CYC BEFORE UT ADJ]	The number of cycles before the robot adjusts the Utool.
R[31:TOTAL CYCLES]	The total number of times the application is run in production.
R[32:Current Cycle]	
R[33:Abort Wear Prog]	Reserved for FANUC.
R[34:Abort\mr_wcomp]	Reserved for FANUC.
R[35:Heartbeat DOUT]	Reserved for FANUC.

B.2 POSITION REGISTER ASSIGNMENTS

This section includes position register assignments for RemovalTool.

Refer to Table B.2 for RemovalTool Position Register Assignments.

Table B.2 Position Register Assignments

Instruction	Description
PR[1:Nominal UTOOL]	The original positions to which all points must be set, without any offsets. The macro `SET NOM UTOOL` sets this value.
PR[2:Incr search dist]	The incremental amount the robot moves to detect wheel wear. Refer to Section 2.6, SEARCH DISTANCE AND DIRECTION FOR WHEEL WEAR
PR[3:Reserved]	
PR[4:Effective UTOOL]	The offset needed after wheel wear plus 1/2 the slide length. The macro `SET EFFECT UTOOL` sets this value.
PR[5:]	
PR[6:Reserved]	
PR[7:Nominal UFRAME]	The Nominal UFRAME is stored here.
PR[8:Effective UFRAME]	The Effective UFRAME (for the bench mounted device) is stored here.
PR[9:]	
PR[10:PERCH POS]	The perch or home position that was set up for the robot system. The macro `MOVE TO PERCH` uses this value.

B.3 I/O ASSIGNMENTS

The recommended I/O assignments are:

Table B.3 Recommended I/O Assignments

Output	Description
DO[1]	For turning the spindle ON/OFF
AO[1]	For extending the passive device (wrist or bench) positive (+)
AO[2]	For retracting the passive device (wrist or bench) negative (-)

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