V55 High-speed Vertical

Machining Center

with Makino Professional 3 Control

Maintenance Guide

This guide is intended for use by Makino customers and Makino employees and assigns for the safe operation and maintenance of Makino equipment.

This guide was developed through the combined efforts of:

Makino R&D Groups - FujiKatsuyama Japan

Makino Documentation Group - Mason USA

TM & Associates (Thos Mercer)

MBS Associates (Lynne Hays & Mark Hebbeler)

Makino Customer Support (Randy Ashley)

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The following icons are used in this document. Safety and precautionary statements are presented as shown below.

A **DANGER** icon precedes each danger statement. A **DANGER** icon indicates an existing hazardous condition with a high probability of death or severe injury. Precautions must be taken immediately to prevent personal injury or death.

A **WARNING** icon proceeds each warning statement. A **WARNING** icon indicates a potentially hazardous situation with some probability of death or serious injury. Precautions must be taken immediately to prevent personal injury.

A **CAUTION** icon proceeds each caution statement. A **CAUTION** icon indicates a potentially hazardous situation with some probability of personal injury or damage to the machine. Precautions must be taken immediately to prevent personal injury or machine damage.

- Precautionary statements must be followed to prevent personal injury or damage to the machine.
- In addition, all safety requirements and guidelines found in Chapter 1 - Safety, the ANSI safety guidelines the Makino Safety Manual, shipped with the machine, and established company safety requirements and regulations must be followed. Taking personal responsibility for safety will prevent most accidents.

Notes are presented using the following icon format

A NOTE icon indicates information that expands on information given or indicates where additional infromation can be found. Notes are presented immediately following the applicable content.

A copy of the ANSI Safety Manual, ANSI document number ANSI B11.8 was shipped with the machine. If this manual was lost or misplaced, another copy can be obtained from Makino at no charge.

Write us at:

Makino
P.O. Box 8003
7680 Innovation Way
Mason Ohio, 54040-8003
Attn: Information Services

Call or FAX us at:

Phone: (513) 573-7200
ask for Information Services
FAX: (513) 573-7360
Attn: Information Services

To contact Makino, for service after the sale:

Makino **7680 Innovation Way** **Mason, Ohio 45040** **USA**	
Technical Support Services	(888) Makino4 (625-4664)
Mon.-Fri. 7:00 a.m. to 8:00 p.m. Sat. 8:00 a.m. to 2:00 p.m. (Eastern Standard Time)	Fax: (513) 459-1825
Parts Express	(888) Makino1 (625-4661)
24 hours, 7 days a week	Fax: (888)-881-9289
Training Services	(888) Makino1 (625-4661)

or contact us on the World Wide Web at: www.makino.com

AVISO!

Las personas que no pueden leer o entender en Ingles deben mandar traducir este manual y solicitar entrenamiento antes de operar o mantener la maquina. Todos los que trabajen en esta maquina deberan saber como operarla con toda seguridad y en forma correcta para evitar un posible dano.

ATTENTION!

Les personnes ne sachant pas lire l'anglais devront se faire lire et expliquer le manuel avant d'utiliser ou de faire l'entretien de la machine. Toute personne travaillant sur la machine doit savoir comment l'utiliser sans danger et correctement afin d'eviter tout accident.

HINWEIS

Alle Personen die nur Teile des Handbuches oder kein Englisch verstenen, müssen sich dieses Handbuch erklären lassen, bevor sie die Maschine in Betrieb nehmen oder instandhalten. Alle Personen, die an der Maschine arbeiten, müssen zur Vermeidung von Verletzungen zur korrekten Handhabung angeleitet werden.

WARNING!

Persons unable to read English or do not understand any part of this guide, must have this guide read and explained to them before operating or maintaining the machine. Everyone working on the machine must know how to operate and maintain it safely and correctly to prevent possible serious injury.

Chapter 1 Safety Precautions

For a Safe Working Environment

Makino V55 High-speed Vertical
Machining Center

MAKINO

Chapter 1
Safety Precautions

Contents

1.1 Overview

This chapter provides proven general safety guidelines that, if followed, promote a safer working environment. It also contains safety information specific to the V55.

All machining centers have inherent hazards the manufacturer either designs out, guards against, or warns about. Even though the manufacturer has this responsibility, the machine user has ultimate responsibility to ensure that a safe working environment is maintained in and about the machining center. This includes, but is not limited to, allowing only properly trained and technically qualified personnel to program, operate and maintain the machining center.

It is Makino's policy and responsibility to design, manufacture, and market machining centers that are as reasonably safe as possible for their intended use.

1.2 General Safety

Safety precautions or requirements discussed in Makino guides or manuals do not supersede any safety requirements imposed by local, state, or federal governments. All government-imposed guidelines, i.e. OSHA (Occupational Safety and Health Administration), NEC (National Electric Code), NFC (National Fire Code), ANSI (American National Standard Institute) standards, shall take precedence.

To protect against injury or damage operate the machining center within the guidelines described in the provided documentation. Consider Makino's safety precautions supplemental to:

- Other Makino supplied guides or manuals related to programming, operation, and maintenance of this specific machining center.
- Your company's safety rules and regulations.
- All local, state, and federal regulations.

Your particular application may require additional safety measures to ensure proper operator safety.

Additional copies of any guide or manual provided with your Makino machining center may be purchased from Makino.

Prior To Installation, Operation, or Service,

Do NOT attempt to install, operate, or service this machining center until:

- You have read and understand the safety instructions contained in this guide.
- You have read and understand all danger, warning, and caution safety labels attached to the machining center and its related equipment.
- You have read and understand all technical information, including the following sections of this safety chapter.

Questions Regarding Safe Operation

Before you operate this machine – contact your Makino service group for answers to any questions about safety and your Makino machine.

1.2.1 Danger, Warning, Caution Statements and Symbols

It is important that all employees recognize each safety symbol on the machine and understand the meaning of danger, warning, and caution.

These safety labels must never be removed, covered or painted over, and must be replaced if they are damaged, defaced, or become unreadable.

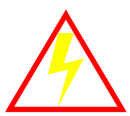
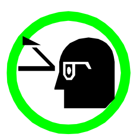
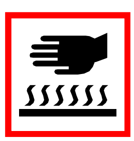
Table 1-1 presents the meaning of each safety statement. It is important that all employees recognize and understand the meaning of the safety symbols shown in Table 1-2.

The location of safety labels for specific hazards on the V55 is described in section 1.9.3 (pg 1-16).

TABLE 1-1 DEFINITION OF DANGER, WARNING, AND CAUTION STATEMENTS

Statement	Meaning
DANGER	DANGER is the most severe safety statement. This statement means that either severe personal injury or death may result if the instruction(s) is not followed.
WARNING	WARNING is the next level of safety statement. It indicates that if the instruction(s) is not followed severe personal injury could result.
CAUTION	A CAUTION is the least severe safety statement and indicates that if the instruction(s) is not followed damage to the equipment may result.

TABLE 1-2 SAFETY SYMBOL SHAPES AND THEIR MEANING

Symbol	Meaning
	A triangle or diamond shaped safety symbol indicates a hazard exists in the area or behind the enclosure where the symbol is placed. The symbol at left indicates an electrical shock hazard exists.
	A solid colored circle shaped safety symbol with an icon inside indicates the action shown by the icon is mandatory. The symbol at left indicates that safety glasses be worn.
	A square shaped safety symbol is used to convey information relative to the area where the symbol is placed. The symbol at left indicates the area is hot.
	A circle shaped safety symbol with a diagonal slash across the image indicates the action shown is prohibited in or around that area. The symbol at left indicates that smoking is not allowed in the area.

1.2.2 Access to Information

We strongly recommend that a copy of these safety instructions and all provided guides, manuals, and technical information be kept near the machine. This information should be organized for quick access and use by operators, maintenance, and other personnel with duties related to the machining center.

Access to this information:

- May save a life.
- Will prevent or reduce injury, mis-operation, and machining center damage.
- In the event that parts of this information become damaged or unusable replace them immediately.

1.2.3 Point-of-operation

"Point-of-operation" should be safeguarded to the greatest extent possible for all machining operations.

In addition to panel locks, interlocks, and guarding; certain areas of the machining center are color coded for safety. It is important that the original color and vividness of these areas be maintained.

Different operations or applications may make the general purpose safeguards unsuitable and require additional safeguards. You and your company are required to use special safeguards in these situations.

To assist in designing point-of-operation safeguards for specific machining center applications:

- OSHA has published a booklet called OSHA Publication No. 3067.
- Films regarding safety requirements for machine tools are available from ANSI and trade groups such as NMTBA (National Machine Tool Builders Association).

1.2.4 Lockout/Tagout Procedure

The machining center is powered by high voltage and other energy sources that represent potential hazards. To reduce the risk of injury or death establish, define, and practice a Lockout/Tagout procedure for the equipment in your facility.

Lockout/Tagout defines a minimum safe procedure to be followed by persons who might be confronted with unexpected energizing, start-up, or release of stored energy that could cause injury or death. At a minimum, all Lockout/Tagout procedures should include:

DANGER

Electrical Shock Hazards Exist - Work Safely

Failure to turn the Main Power disconnect to the Off position, lock it out, and tag it could result in severe personal injury or death.

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1. Set the machine’s Main Power switch to the Off position.
2. Affix a DO NOT START tag with your name and department at, on, or near the machine’s Main Power switch, until all repairs are complete.
3. Turn the Main Power disconnect to the Off position.
4. Install an industry approved lockout device through the Main Power disconnect handle.
5. Install a tamper-proof padlock onto the lockout device. All persons performing maintenance on the machine at the same time shall install their own padlock onto the lockout device.
6. Disconnect the main power of all power sources (i.e. electrical, air, hydraulic, etc.).

Use the Lockout/Tagout policy and procedures defined by your company. If no Lockout/Tagout procedure has been communicated to you, please ask your supervisor to provide and explain one or obtain copies of standards to develop and implement lockout/tagout in your plant.

- ANSI has issued a standard to assist in the design and development of a Lockout/Tagout policy. It is written as a guide to follow when determining the specific procedures and training necessary and appropriate to your plant operations.
  - Copies of the ANSI standard are available from ANSI at 1430 Broadway, New York, NY 10018, ask for: Standard ANSI Z244.1-1982, or as modified, for personal protection - Lockout/Tagout Of Energy Sources - Minimum Safety Requirements.

1.3 Personal and Professional Safety

General safety precautions should be practiced everyday, but never become common place. Safety is the responsibility of every person on the job site. In this regard, consider yourself responsible for safety in your workplace. No one is better positioned to eliminate or prevent unsafe conditions than you. Each employee should practice the following, regardless of their position, title, or labor grade:

- Approach and intercede anytime you witness unsafe procedures.
- Be prepared to report any condition which seems unsafe to your company's safety department or any supervisory or management staff. It could save lives. In particular report such things as:
  - Missing or defective guards and protective devices.
  - Leaks and spills of cutting fluid, lubricants, or any liquids.
  - Improperly stored chemicals or flammable materials and any unusual fumes.
  - Loose, worn, or broken flooring.
  - Slippery, broken, or unstable platforms.
  - Missing, broken, or unstable handrails.
- Avoid making sudden movements, loud noises, engaging in horseplay, or other activities that may prove distracting and result in an unsafe or dangerous work environment. Remember, that around machinery, it only takes a second's inattention to result in personal injury or death.
- Observe and obey all signs posted on the machinery and its components and signs placed by your company, like:
  - NO SMOKING
  - SAFETY GLASSES MUST BE WORN WHILE OPERATING THIS MACHINE
  - DANGER - HIGH VOLTAGE, etc.
- Wear appropriate safety equipment as defined by OSHA, the equipment manufacturer, your company safety policy, or MSDS (Material Safety Data Sheet). Always wear approved eye protection and other safety equipment to meet the demands of current conditions while operating or working around the machining center.
- Clean up any oil or other liquid spills immediately.

- Obtain an MSDS for each chemical (such as cutting fluids, lubricating oils, greases, etc.) used on or around the machining center. Practice safe working habits and wear all protective equipment required. Know and understand the procedures to follow in the event:
  - Your skin is exposed to the chemical.
  - Your eyes are contacted by the chemical.
  - You ingested or inhaled the chemical.

1.4 Equipment and Operation Safety

We urge that all machining centers be operated, equipped, and cared for in strict compliance with all local, state, and federal safety regulations. The following safety requirements apply to all machinery and should be practiced in addition to machine specific safety guidelines.

- Do not neglect your responsibility to ensure that all machining centers are operated, maintained, and equipped with complete regard for operator safety.

Only qualified personnel, trained in safety and all machining center functions should be allowed to operate, maintain, or repair the machine.

To be considered qualified, all personnel whose duties are related to the operation, maintenance, or repair of the machining center should:

- Be made familiar with the location and operation of the **[EMERGENCY]** buttons (E-Stop).
- Study the related guides or manuals prior to attempting to operate, maintain, or repair the machine. A recommended reading list by job type for your machine model is provided in section 1.14.
- Locate and understand all danger, warning, and caution labels on the machining center and accessories.

Machining centers are designed for operation by one person at a time.

- Persons other than the designated operator should stay out of the area during operation.
- Unauthorized personnel may increase the potential for injury or damage due to inattentiveness.

Be sure to Always:

- Take steps to protect the machine tool and control cabinets from moisture and condensation. Moisture can damage electrical components, causing unwanted machine motion, leading to injury or machine damage.
- Maintain the exact original color and vividness of any machining areas that are color coded as safety precautions.
- Ensure that all shields and guards are in place and all covers, cabinet doors, and terminal boxes are closed prior to operation.
- Avoid accidentally bumping or touching any machine controls, as this may cause unintended machine motion causing injury or machine damage.
- Be alert for loose, damaged, or worn parts on the machine and associated equipment. Immediately correct or report any; loose items, noticeable change in operating noise, or any unusual machine action.
- Be aware of the machine and auxiliary component's moving members and range of movement which may create pinch points. Always be cautious of these areas. Avoid pinch points entirely during machine operation.
- Keep the machining center properly maintained. Perform maintenance at prescribed intervals, as described in the Maintenance Guide. Machining center maintenance should be performed only by authorized individuals.
- Check the level of each fluid reservoir periodically. Add fluids, if needed, as described in the Maintenance Guide. Use only recommended lubricants.
- Keep the machining center clean. Keep the work area clear of chips, rags, etc. Cleaning should be performed, at least, daily.
- Keep away from the ATC (Automatic Tool Changer), APC (Automatic Pallet Changer), and other exchange devices while the machine is in automatic operation.
- Double check the set up, tooling, and workpiece before power up.
- Check all clamp bolts for tightness and verify the accuracy of all set ups before restarting machining operation.
- Use caution when handling workpieces, after machining. Machining can produce sharp edges and at times considerable heat.

You should:

- Never wear loose-fitting clothing or accessories that may be entangled in cutting tools, revolving parts, conveyors, or other machine components. In particular, never wear any of the following items when working in a shop environment:
  - Jewelry (rings, bracelets, watches, or necklaces) and accessories (necktie, scarf, or loose fitting belt)
  - Long hair (tie it back and contained under a hair net or cap)
- Never operate any machinery after taking strong medication, using nonprescription drugs, or consuming alcoholic beverages.
- Do not make modifications to the machine or associated equipment that may reduce the operational safety of the device such as:
  - Never paint, alter, deface, or remove any danger, warning, or caution label. (Replacement labels are available from Makino)
  - Never change or by-pass the location of the stroke limit dogs, limit switches, interlock circuitry, etc.
  - Never operate the machine with any safety device disabled or removed or any cover open or removed
- Do not allow yourself to become trapped or caught in pinch points:
  - Always be aware of a safe exit, when in or around any type of equipment. Know the travel limits of the machining center and always keep all body parts clear of moving components.
  - Never enter an area restricted by a barrier without first properly shutting down the equipment and locking out the power sources to prevent its being restarted.
  - Never perform any set up, set up check, reach into the work area, or across moving parts while the machine is in automatic operation.
  - Never change a workpiece or perform a manual operation on a workpiece while the machine is in automatic operation.
- Never activate or press any button or other operating control unless you are trained on the operation of that device, machine, or equipment.
- Never apply excessive pressure or force to tools or tool holders while they are positioned in the spindle.
- Never use compressed air to clean or blow chips or dirt off the table, workpiece, or the machining center.

1.5 Environmental Safety

Follow these specific practices when working at the machining center:

- The area around the machine should be well lighted, dry, and free from obstructions. Keep the area around the machine clean and in good order at all times.
- Equipment should not be operated during severe thunderstorms or other electrical disturbances.
- In the event of a power failure, turn the Main Power switch Off immediately. Leave the switch in the Off position until the power is fully restored and normal operations can safely be resumed.
- Never step on machine covers as they can become slippery during normal operation and are not designed to support your weight.
- Never perform grinding operations in the vicinity of the machining center. The dust created by grinding can contaminate components, cause premature wear, and cause inaccuracies or component failure.
- Never weld on parts mounted on or in the machine. Electrical currents associated with welding could cause bearing damage or explosions and result in serious injury or equipment damage.
- When a platform is placed around the machining center, it should be extremely sturdy, safe, and have anti-slip surfaces.
- Keep all flammable liquids away from the work area.

1.6 Lifting Safety

These lifting safety precautions must be followed by all persons responsible for lifting. This includes, but is not limited to lifting machinery, machine components, and workpieces:

- All lifting equipment must be properly rated for the weight being lifted.
- All lifting equipment must be inspected on a regularly scheduled basis.
- Any lifting device found to be defective must be repaired in accordance with industry standards.
- Any lifting device that cannot be repaired must be destroyed.

1.6.1 Slings

Use nylon slings when lifting irregular shape objects and:

- Never exceed the lifting capacity of any sling.
- Protect slings with heavy padding when lifting objects with sharp edges.

1.6.2 Chains

Lifting chains must be stored properly to prevent damage when not in use.

When using chains:

- Never exceed the lifting capacity of any chain.
- Do not drag chains.
- Do not allow chains to become tangled or kinked.
- Never twist chains in an attempt to shorten their length. Use proper devices to shorten a chain’s length.
- Use chains equipped with enclosed lifting hooks.

1.6.3 Hooks

When using hooks:

- Never exceed the lifting capacity of any lift hook.
- Do not repair lifting hooks.
- Destroy and discard bent lifting hooks.

1.6.4 Eye Bolts

To ensure a safe load carrying capacity:

- Never exceed the lifting capacity of any eye bolt.
- An eye bolt must be engaged to at least 90 percent of its threaded portion.
- Never weld or heat an eye bolt to a temperature in excess of 480° C (900° F). Heat exposure can change the physical properties of the stock and create an unsafe eye bolt.
- Never use an inch eye bolt in a metric thread or vice versa:
  - Use inch series thread eye bolts in inch series threads.
  - Use metric series thread eye bolts in metric series threads.
- Never use a painted or coated eye bolt as this may cover up defects.
- Discard and destroy any defective eye bolts.

1.6.5 Rings

When possible use a lifting ring or clevis instead of an eye bolt. Secure the lifting ring with the correct inch/metric series bolt.

- Never exceed the lifting capacity on any lifting ring or clevis.

1.6.6 Lifting the Machine or Components

Use only a lifting device and related equipment that is capacity rated to lift the total weight of the machining center (and shipping skid, if the skid is attached during lifting). Always follow the lifting instructions provided in this Pre-Installation Guide.

Before lifting, refer to shipping documents to obtain the weight of the machine or component being lifted. If the necessary weights cannot be determined, consult Makino. In addition:

- Only qualified riggers should perform machine lifting operations.
- Never place any portion of your body beneath a suspended object.
- Lift the machining center only at the designated lifting points.
- Never lift the machine higher than necessary.
- Always maintain the center of gravity, by properly adjusting the leg lengths of the lifting device.

1.6.7 Lifting Workpieces and Fixtures

Always use a lifting device and related lifting equipment that is capacity rated for the workpiece or fixture being lifted.

- Never place hands, arms, feet, or any other portion of your body beneath a suspended workpiece fixture.
- Always maintain the center of gravity by properly adjusting the leg lengths of the lifting device.

1.7 Mechanical Maintenance Safety

Mechanical maintenance procedures for Makino machining centers should be performed by properly trained and technically qualified personnel. They should adhere to these specific practices when working with the machining center:

- Always perform a Lockout/Tagout procedure before removing any safety guard, cover, barrier, or any basic component of the machining center. See section 1.2.4.
- Block vertical sliding members before disassembling any portion of their drive train.
- Be familiar with and adhere to safe lifting practices described in section 1.6 before lifting the machine or components.
- Never return the machining center to production until all safety guards, covers, barriers, or other safety devices are reinstalled and confirmed operational.

Mechanical Maintenance Equipment

Mechanical maintenance personnel should:

- Keep all hand tools in good repair.
- Use each hand tool in a manner for which it is intended.
- Never use any hand tool that is defective, broken, or worn out.
- Keep alert with regard to nearby hazards.
- Do not use extenders in an effort to gain leverage; use a bigger tool.

1.8 Electrical Maintenance Safety

Electrical maintenance procedures for Makino machining centers must be performed by properly trained and technically qualified personnel. They should adhere to these specific practices when working with the machining center:

- Always perform the Lockout/Tagout procedure before working on electrical circuits. See section 1.2.4.
- Use extreme care, when troubleshooting with power On.
- With the power Off, identify and discharge any power retaining devices, such as capacitors, before starting any maintenance procedure within any electrical control cabinet.

Electrical Maintenance Equipment

Use only industry standard approved electrical testing equipment.

- Volt/Ohm Meters.
- Oscilloscopes.
- Static Ground Wrist Straps.

Machine Grounding

All Makino machining centers must be properly grounded at the time of installation.

- Proper grounding requires an isolated earth ground.
- Ground the machine in accordance with local, state, and federal regulations.

Machine Electrical Devices

Always replace defective electrical components, such as fuses, shunts, overloads, etc., with components of the same capacity and rating as the original equipment. If you are unsure of the correct electrical component or part, refer to the machine’s electrical drawings or consult Makino.

1.9 V55 Vertical Machining Center Safety

In addition to safety precautions for all machining operations, the energy generated by HSM (High-Speed Machining) requires special safety considerations that must be fully understood by the operator.

1.9.1 Machine Safety Features

The Makino V55 provides the following safety features:

- Manual handle interrupt buttons, located on auxiliary operation panels, to prevent automatic operation of that unit, when active.
- S/G (Splash Guard) door interlocks, to halt machining operations when the splash guard doors are opened.
- **[EMERGENCY]** buttons, to immediately halt all machine functions.

Descriptions, operational detail, and precautions related to these safety features are described in the Operation Guide.

1.9.2 Location of Emergency Stop Buttons

[EMERGENCY] buttons are located, as shown:

- Main operation panel – Figure 1-1.
- ATC (Automatic Tool Changer) operation panel – Figure 1-2.
- MTC (Machine Tool Cabinet) door – Figure 1-3 (pg. 1-18).
- MPG (Manual Pulse Generator) [option].
- APC (Automatic Pallet Changer) operation panel [option].

1.9.3 Location of Safety Labels

Labels attached to the machine at specific areas, identify safety risks and provide important instructions that must be read and followed.

- S/G Door – Figure 1-1.
- Front of Spindle – Figure 1-4 (pg. 1-18).
- ATC Magazine Door – Figure 1-2.
- Scraper Conveyor – Figure 1-3 (pg. 1-18).
- Lift-up Chip Conveyor [option] – Figure 1-5 (pg. 1-19).

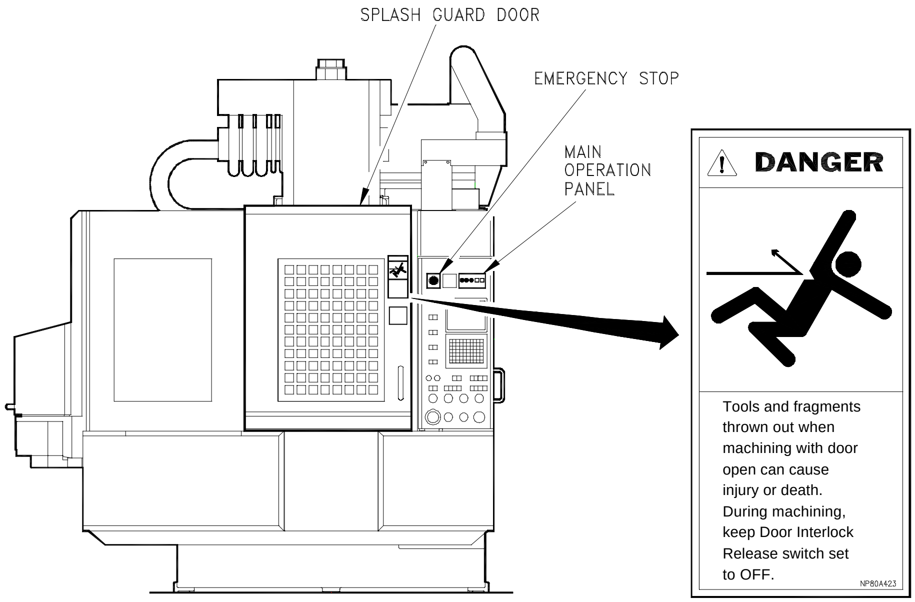


FIGURE 1-1 SPLASH GUARD DOOR SAFETY LABEL AND OPERATION PANEL E-STOP BUTTON

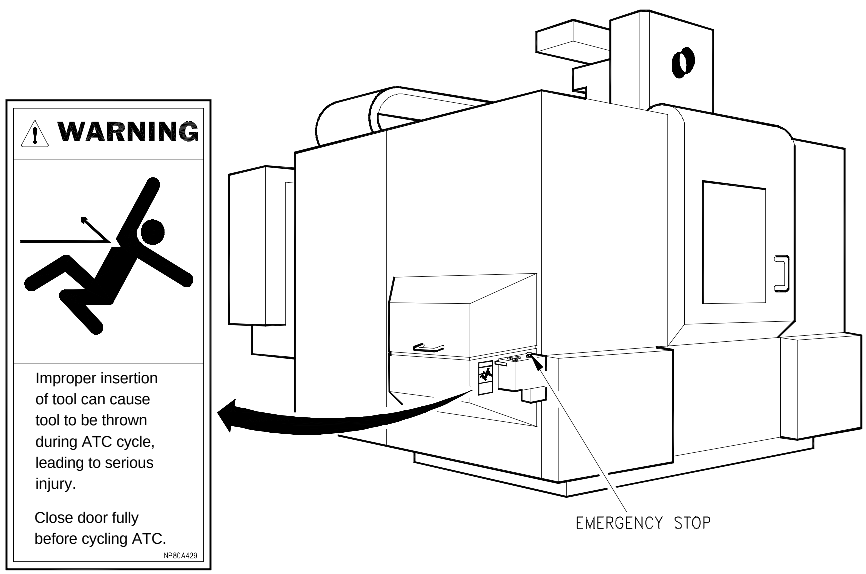


FIGURE 1-2 ATC MAGAZINE DOOR SAFETY LABEL AND E-STOP BUTTON

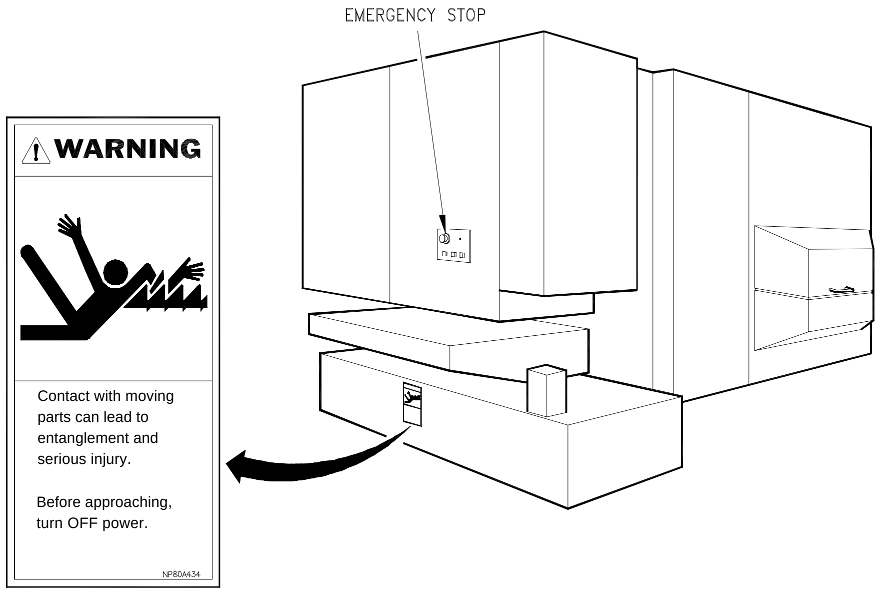


FIGURE 1-3 SCRAPER CONVEYOR SAFETY LABEL AND MTC E-STOP BUTTON

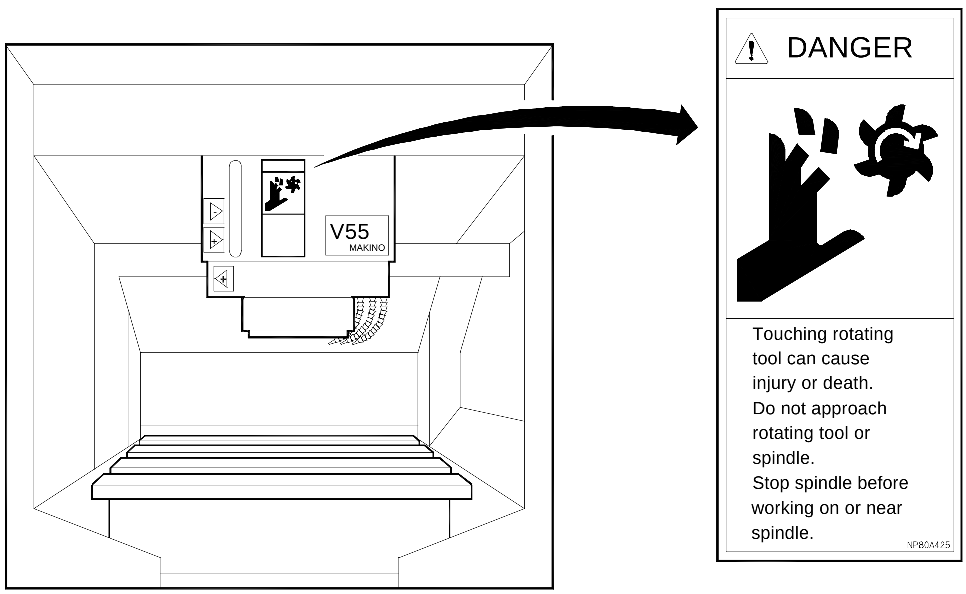


FIGURE 1-4 FRONT OF SPINDLE SAFETY LABEL

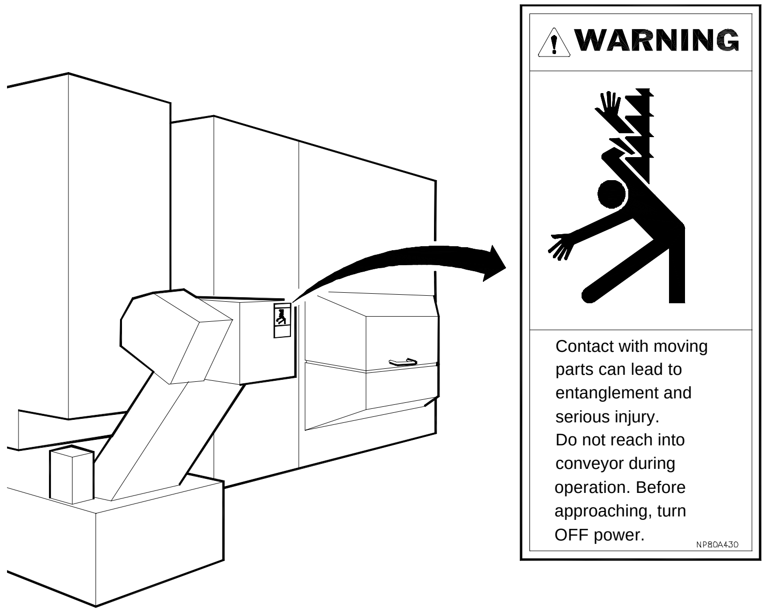


FIGURE 1-5 LIFT UP CHIP CONVEYOR SAFETY LABEL

1.10 Tooling Safety

Standard Tooling Safety Precautions

Always:

- Inspect all tool holders for nicks or other damage to ensure the accuracy of machining operations and prevent damage to the equipment.
- Keep the spindle taper and tool holders clean.
- Use sharp tools and keep tool lengths as short as possible.
- Use speeds and feeds appropriate for cutting conditions and tooling limitations.
- Use a glove or shop cloth and avoid the cutting edges when handling or changing tools.

You Should:

- Never reach into the machining area, until the spindle is at a complete stop.
- Never operate the machining center while wearing gloves or using a shop cloth.

High-speed Machining Tooling Safety Precautions

HSM requires additional tooling safety precautions:

- Operators should receive training to ensure a solid understanding of the potential energy generated in HSM applications and observe proper safety practices.
- All tools placed in the spindle should be rated for the maximum spindle rpm. Using tooling rated for maximum rpm prevents unsafe conditions due to improper spindle speed selection.
- Balance all tooling to Makino's recommendation.
- Not all tools are designed for HSM and balancing alone will not make them safe for this application.
    - Confirm suitability for high-speed application with the tool manufacturer.
    - Balance the entire tool assembly to prevent stacking component tolerances.
- When machining at high-speed with inserted tools:
    - Tooling must be rated for the maximum spindle speed available.
    - All inserts should be screwed directly to the cutter body (screw down). Clamps are insufficient at high rpm.
    - Fasten inserts at the manufacturer's recommended torque with the recommended anaerobic sealing compound, to prevent loosening.
    - Routinely replace mounting screws to avoid material fatigue.

1.11 Equipment and Operation Safety

In addition to the general safety precautions in section 1.2, adhere to these specific practices when working with the V55.

- Never use any device not specifically designed for the intended use.
- Never replace tooling or tighten tool holders in the spindle.
- Never lay tools on the machine where they may interfere with machine movement or become entangled with the workpiece.
- Never exceed the specified maximum workpiece weight.
- Never perform any set up work while the machine is in operation.

Working Inside the Machine

When working inside the machine be aware that axes, spindle, ATC or APC, and chip conveyor operation and flying chips or coolant are hazards that could result in serious injury or death. Therefore:

- Enter the machining area only when all machine motion is completely stopped and the control is in the STOP or RESET state.
- Be careful not to slip on the tilted telescopic covers.
- Remember injury can occur if the body is caught between the S/G door and the frame.
- Avoid coolant on ceiling from dripping into the eye.

Prior to Machining

- Check with the manufacturer of any accessory not designed, built, or supplied by Makino to ensure the device will operate properly and safely under the proposed operating conditions.
- Load or unload workpieces only when the machine is completely stopped and the control is in STOP or RESET status.
- Prior to unattended operation, prove out part programs to ensure clearance between machine parts, fixturing, and the workpiece.
- Before moving the ram (Z axis), saddle (X axis), or table (Y axis), make sure there are no obstructions within the range of movement.
- Verify the accuracy of the set up, prior to automatic operation. Check the tightness of all clamping devices, fixture mounting, tool holders, etc.

Workpiece Handling Safety

These specific lifting safety precautions must be followed by all personnel responsible for lifting workpieces. In addition to the general lifting precautions in section 1.6 adhere to these specific practices with the V55:

- The V55 has a maximum allowable table capacity of 700kg (1,543lb). Never exceed this weight limit.
- Load and unload workpieces or fixturing only when the machine is completely stopped and the control is in STOP or RESET status or the Main Power switch is Off.
- Use lifting equipment for heavy workpieces and other materials. Never attempt to lift anything beyond a reasonable weight without proper devices.
- Use extreme care not to place fingers or hands where they may be pinched while loading or unloading a workpiece.

1.12 Coolant Safety

The V55 comes with several coolant options. Follow these safety guidelines with all possible coolant configurations:

Always:

- Adjust coolant lines and flow, only when the spindle and machine are at a complete stop and the control is in STOP or RESET state.
- Select a water soluble coolant, whenever possible. Oil based coolants or cutting oils may, under certain conditions, create a fire hazard.
- Be careful when handling coolant fluids. In some instances these fluids have caused irritation and harmful effects to skin. Persons with any type skin allergy or sensitive skin should not handle coolants, without proper protection.
- Avoid breathing coolant.
- Read and apply the proper handling methods described in the coolant's MSDS.

1.13 Installation Safety Instructions

The following information is related to installation of the machining center. Adhere strictly to the installation instructions provided in the Pre-Installation Guide:

- Review the general lifting safety rules in section 1.6 and the specific procedures in the Pre-Installation Guide, prior to moving the machine.
- Review the general electrical safety rules in section 1.8 and the specific procedures in the Pre-Installation Guide, prior to connecting power to the machining center.

1.14 Required Reading

Each person assigned to operate, maintain, or repair a machining center should first read the guide that is appropriate for their responsibility listed in Table 1-3.

TABLE 1-3 REQUIRED READING

Manual Title	Publication No.
V55 Pre-Installation Guide	1560
V55 Maintenance Guide	1563
V55 Operation Guide	1564
Programming Manual for Horizontal/Vertical Machining Centers With Fanuc Computer Numerical Control	0794
Data Server - DNC Function User’s Guide †	1431
† Required if you selected the optional Data Server.	

In addition, you should, read any User Guide or other manuals specific to your machine configuration.

NOTES:

SKETCHES:

Chapter 2 Specifications

Machine Unit and Control Specifications

Makino V55 High-speed Vertical
Machining Center

Chapter 2
Specifications

Contents

2.1 Overview

This chapter contains the specifications for the machine's main components (units), the control, and external dimensions and floor plans for the machining center and its various optional features.

Information Subject to Change

Every effort was made to ensure the accuracy of the data presented in this chapter at the time of its publication. Machine and control specifications are subject to change without prior notification.

2.2 Unit Specifications

Specifications for each machine unit are provided below. These specifications are collected here to serve as a quick reference. For more detail on unit; design, principle of operation, and maintenance refer to the related mechanical chapter for that unit.

2.2.1 Spindle

The V55 11A spindle is a 14,000 rpm (standard) and available in a 20,000 rpm version (option). the spindle is driven by an integral AC motor. The spindle has a positive mechanical clamping mechanism to securely retain tooling and electric orientation system to facilitate automatic tool changes.

Spindle specifications are provided in Table 2-1. Figure 2-1 shows the spindle motor output characteristics.

TABLE 2-1 SPINDLE SPECIFICATIONS

Item	Specification	(approx. US)
Spindle Speed Range	15 – 14,000 rpm	
Number of Speed Ranges	Continuous with two step electric changeover	
Acceleration Time	0.8 sec at 7,000 rpm and 2.3 sec at 14,000 rpm	
Deceleration Time	0.7 sec at 7,000 rpm and 1.6 sec at 14,000 rpm	
Taper	7/24 No. 40 [standard] HSK-A63 [option]	
Bearings [Inner / Outer Diameter]	90/140 mm	(3.5 / 5.5")
Integral Motor Output Characteristics [15min. Duty Cycle / Continuous]	AC 22 / 18.5 kW	(30 / 25 hp)
Orientation	Electric Servo Type	
Tool Clamp Force	9.8 kN	(1 ton)
Torque Characteristics [25% ED / Continuous]	166 / 95.1 N·m	(37.3 / 21.4 lbf)
Cooling and Lubrication		
Spindle Shaft	Core cooling and under race lubrication	
Head	Jacket cooling	
Temperature Controller	Synchronized with bed temperature	

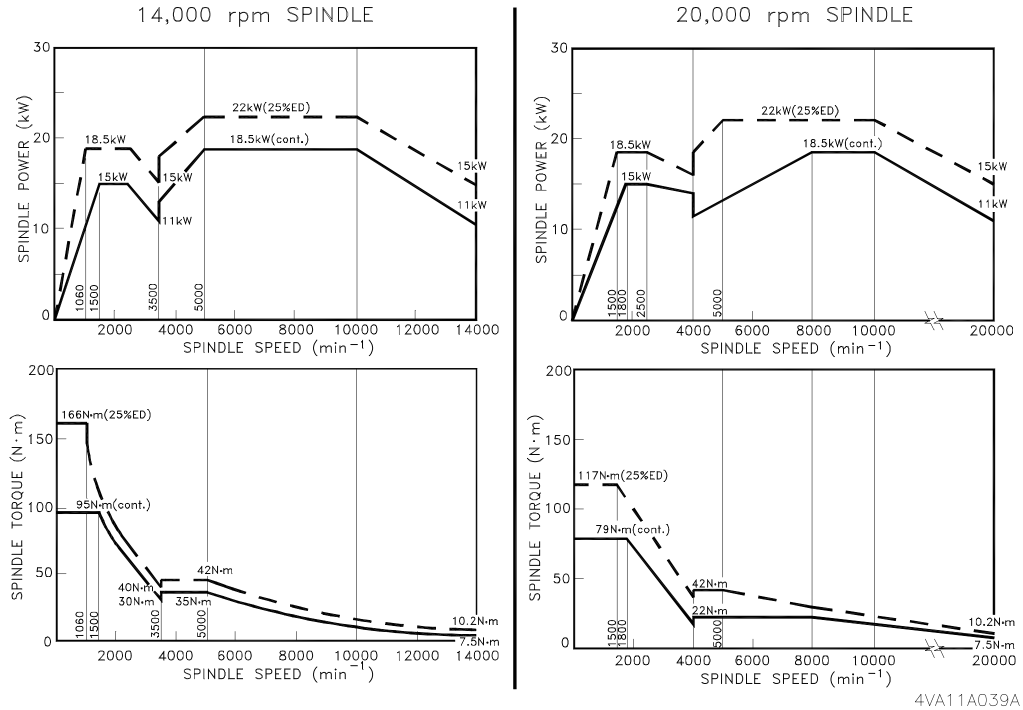


FIGURE 2-1 SPINDLE POWER AND TORQUE CHARACTERISTICS

2.2.2 Axes Components

The spindle head, column, and table form the axes of the Cartesian coordinate system, which is the basis for modern machining. Figure 2-2 shows axes configuration and work cube. Machine travel specifications are listed in Table 2-2.

The V55 uses a Fanuc digital servo system with 3.5 kW AC servo motors. This servo system reach full rapid traverse (50,000mm/min. (1968 ipm)) in less than 38mm (1.5") of travel, while maintaining positioning accuracies.

TABLE 2-2 AXIS TRAVEL SPECIFICATION

Item	Specification	(approx. US)
X Axis Travel [Saddle]	900 mm	(35.4")
Y Axis Travel [Table]	500 mm	(19.7")
Z Axis Travel [Ram and Spindle]	450 mm	(17.7")
Distance from Spindle Nose to Table Surface [Minimum - Maximum]	150 - 600 mm	(5.9 - 23.6")
Location of Reference Position for All Axes	+End of Stroke	

2.2.2.1 Accuracy

Table 2-3 lists standard machine accuracies. Accuracies are checked before shipment and require proper installation, foundation, environment, and maintenance to be maintained or guaranteed.

TABLE 2-3 MACHINE ACCURACY

Item	Specification	(approx. US)
Linear Positioning †		
Full Stroke	±5 microns [0.005mm]	(±0.0002")
Full Stroke With Scale Feedback	±2 microns [0.002mm]	(±0.000080")
Repeatability †		
Full Stroke	±2 microns [0.002mm]	(±0.000080")
Full Stroke With Scale Feedback	±1.5 micron [0.0015 mm]	(±0.000060")
† Above accuracies are static positioning checks and can only be guaranteed when machine is installed, operated, and maintained under proper conditions.		

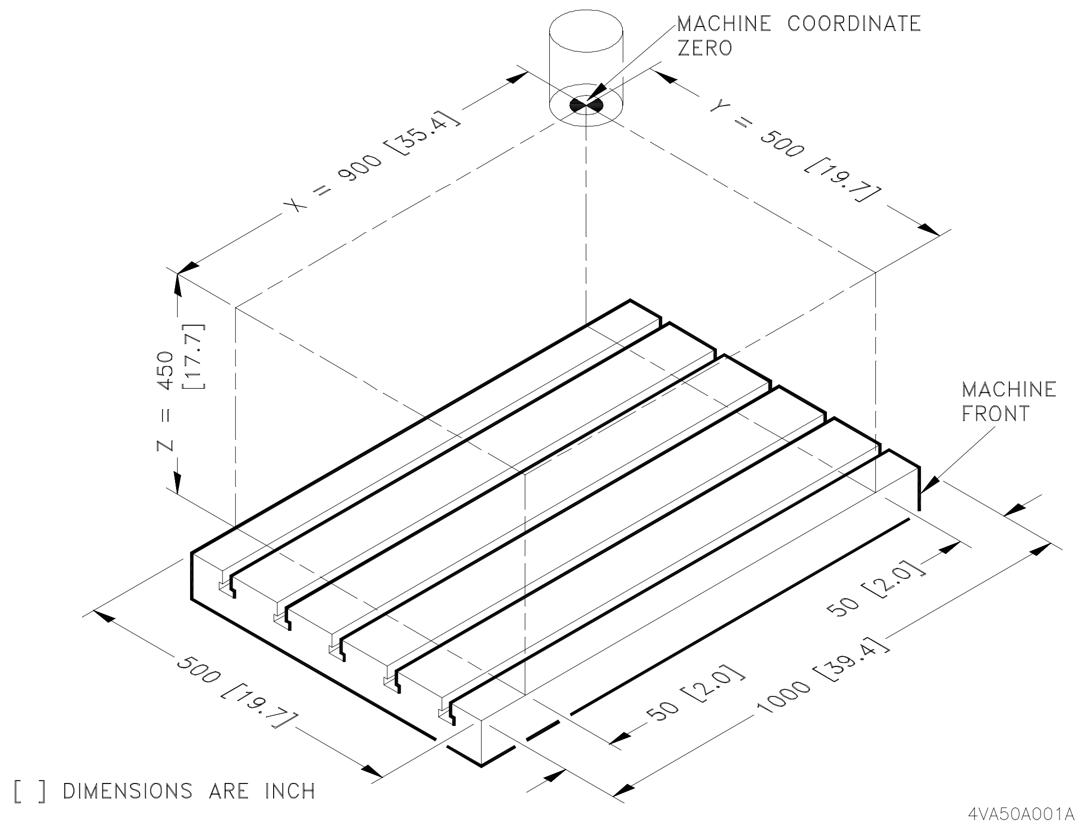


FIGURE 2-2 AXIS CONFIGURATION, TRAVEL, AND WORK CUBE

2.2.3 Table

Table specifications are listed Table 2-4 and shown in Figure 2-3.

Workpiece size limitations are shown in Figure 2-4.

TABLE 2-4 TABLE SPECIFICATIONS

Item	Specification	(approx. US)
Table Dimensions [L × W]	1,000 × 500 mm	(39.37 × 19.7")
T-Slots, Five	18 × 35 × 30 mm	(0.71 × 1.38 × 1.18")
Table Weight	70 kg	(31.75 lb)
Height to Table Surface	980 mm	(38.6")
Workpiece Maximum Weight [Equally Distributed]	700 kg	(1,543 lb)
Workpiece Size [L × H × W]	1,000 × 630 × 50 mm	(39.37 × 24.8 × 17.7")

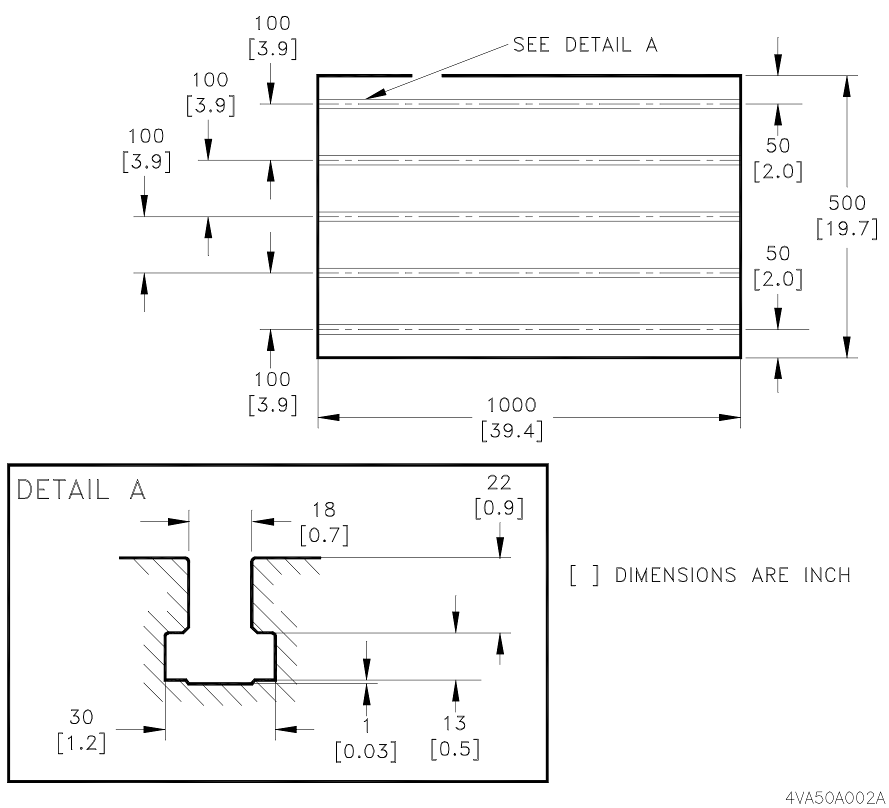
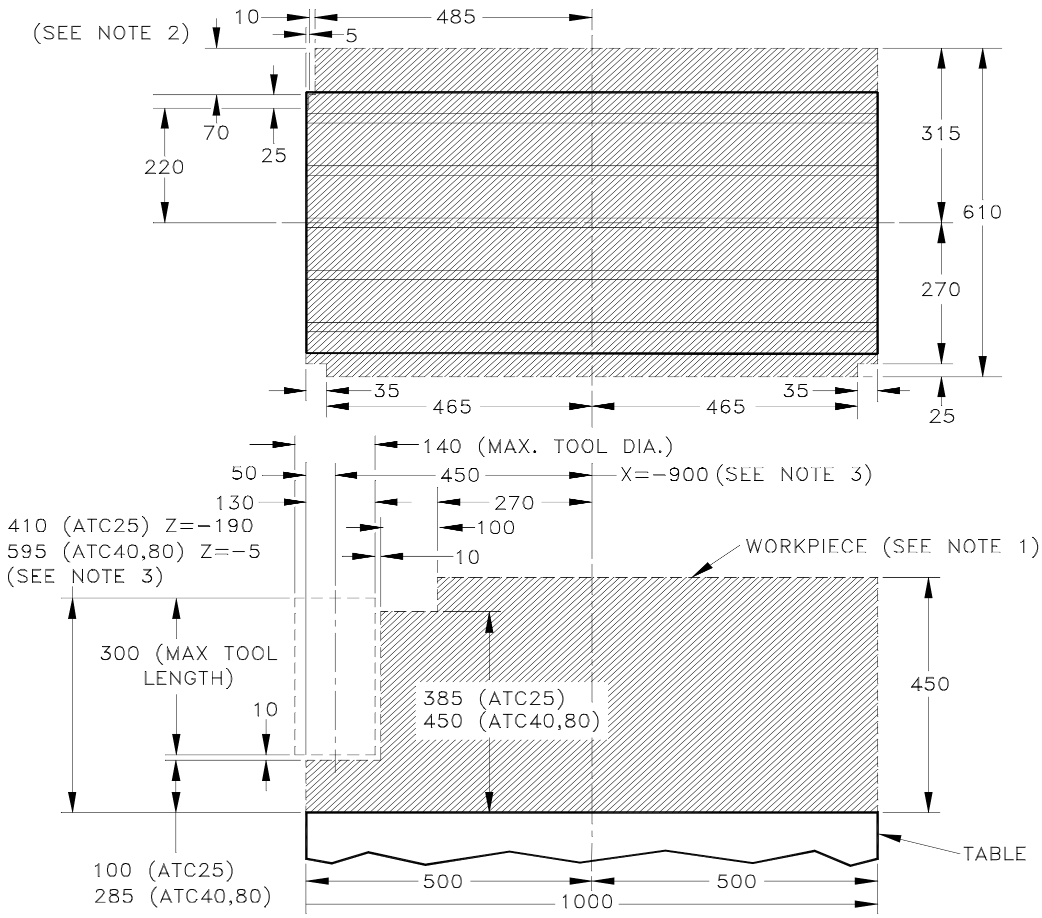


FIGURE 2-3 TABLE AND T-SLOT DETAIL



NOTES:

1. SHADED AREA IS MAXIMUM WORKPIECE ON TABLE.
2. LIMITATIONS IN PLAN VIEW, LEFT FAR SIDE CORNER, APPLY IF MACHINE IS EQUIPPED WITH AUTOMATIC TOOL LENGTH MEASURING UNIT.
3. ATC (AUTOMATIC TOOL CHANGER) CHANGING POSITION COORDINATE.

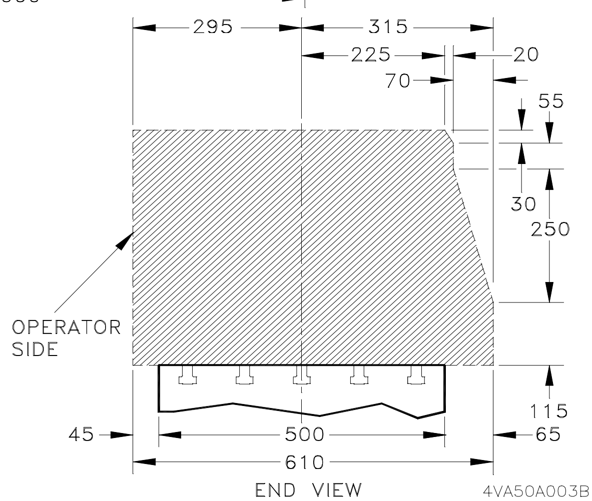


FIGURE 2-4 WORKPIECE SIZE LIMITATIONS

2.2.4 Automatic Tool Changer

An ATC (Automatic Tool Changer) provides several advantages in extending no or low-attendant machining, automating multiple operations, assigning spare tools for long job runs, etc.

Table 2-5 lists the ATC specifications and Figure 2-5 illustrates tool limitations.

TABLE 2-5 STANDARD 25-TOOL ATC SPECIFICATIONS

Item	Specification	(approx. US)
Tool Selection Method	Fixed Address Indexing	
Tool Storage Capacity	25 Tools, Armless	
Tool Shank	40T [JIS B6339] or BT40 [MAS403] - [Std] HSK A-63 - [Option]	
Type of Retention Knob	40P [JIS B6339] or P40TI [MAS403]	
Tool Change Time Tool-to-Tool	1.5 seconds	
Tool Change Time Chip-to-Chip	3.9 seconds	
Limitations †		
Maximum Tool Weight [Including shank]	8 kg	(17.6 lb)
Maximum Tool Diameter [Unconditional]	120 mm	(4.7")
Maximum Tool Diameter [Adjacent pockets empty]	140 mm	(5.5")
Maximum Tool Length	300 mm	(11.8")
† Manually change any tool that exceeds the weight, diameter, or length limitations.		

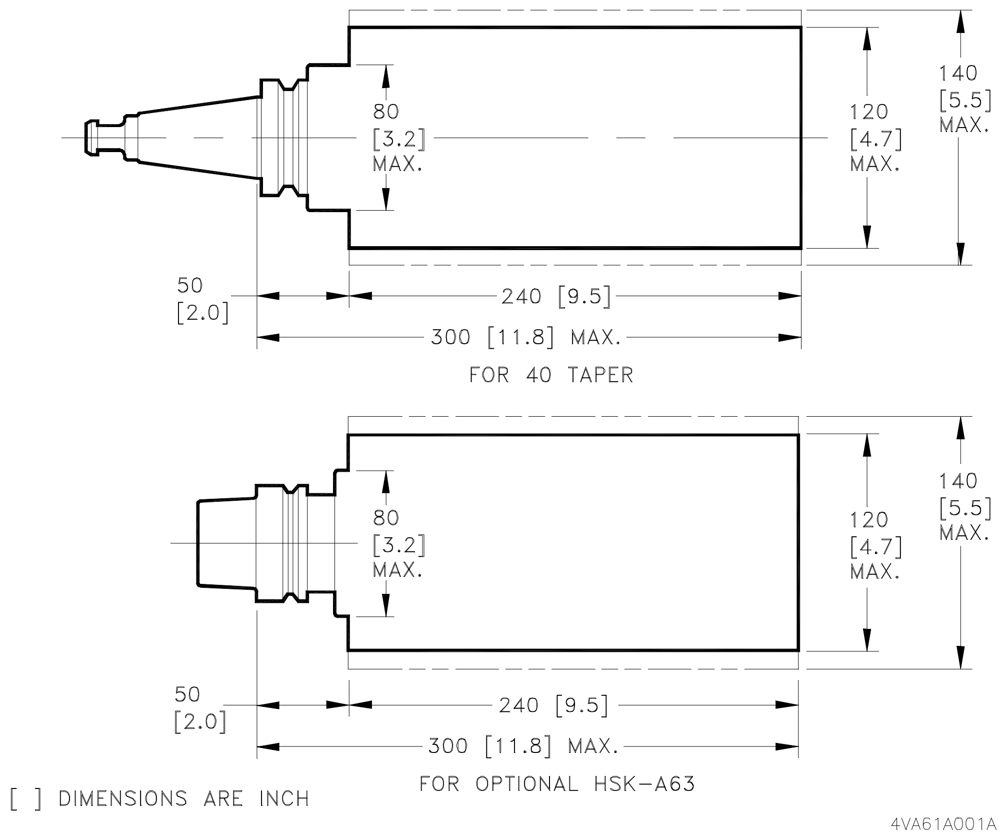


FIGURE 2-5 AUTOMATIC TOOL CHANGER TOOLING LENGTH AND DIAMETER LIMITATIONS

2.2.5 Oil Controller

Oil controller specifications are listed in Table 2-6.

TABLE 2-6 SPINDLE OIL TEMPERATURE CONTROLLER SPECIFICATION

Item	Specification (approx. US)	
Cooling Capacity	7270/8370 W (50/60 Hz)	
Cooling Compressor	2.2 kW	(2.95 hp)
Tank Capacity	30 L	(7.9 gal.)
Motor Capacity	0.75 kW by 3	(1 hp by 3)

2.2.6 Hydraulic Unit

Hydraulic unit specifications are listed in Table 2-7.

TABLE 2-7 HYDRAULIC UNIT SPECIFICATIONS

Item	Specification	(approx. US)
Maximum Operating Pressure	7 MPa	(1,015.2 psi)
Discharge Rate	20/24 L/min.	(4.4/5.3 gal./min)
Tank Capacity	10 L	(2.2 gal.)
Motor Capacity	2.2kW	(2.95 hp)

2.2.7 Coolant Unit

Water-based coolant is recommended for this machining center to avoid the possibility of fire. Please consult Makino before using an oil-based coolant. Coolant system specifications are listed in Table 2-8.

TABLE 2-8 COOLANT UNIT SPECIFICATIONS

Item	Specification	(approx. US)
Number of Nozzles	8 Places on Spindle Head	
Pump Discharge Rate [50/60Hz]	50/60 L/min.	(13.2/15.9 gal./min)
Pump Discharge Pressure	0.4 MPa	(58 psi)
Tank Capacity without Conveyor [total / effective †]	550 / 445 L	(145 / 118 gal.)
Motor Capacity [50 / 60Hz]	1.06 / 1.21 kW	(1.4 / 1.6 hp)

† Total means capacity of tank at initial fill. Effective means capacity that pumps can intake.

2.3 Makino Professional 3 Control

The Makino Professional 3 (PRO 3) control provides user friendly features with Custom side PMC functionality and vivid graphic displays. Standard configuration of the control is listed below.

2.3.1 Control Panel

Feature	Detail
LCD and MDI Panel	16M Fanuc with 9 inch Color LCD
	Clock Function
	MDI Function
	Flexible Control Panel
	Run Hour and Parts Count Display
Routine Functions	Tool Call by 4 Digit T Command
	All Axis Automatic Reference Return
	Automatic Tool Change
	Automatic Return to Reference Point (all axes) or Work Setting Position
Machine Operation Panel	Single Block
	Program Stop- M00
	Optional Stop- M01
	Optional Block Skip With - / and Label Skip
	Dry Run
	Machine Lock
	Z-axis Feed Cancel
	Auxiliary Function Lock
	Manual Absolute
	Program Restart
	Memory Protect Key

2.3.2 Custom Side Features

Feature	Detail
Makino Functions	Tool Life Monitor
	Spare Tool Selection
	GI (Geometric Intelligence)
	SGI (Super Geometric Intelligence) (option)
	Adaptive Control
	Spindle Load Monitor
Enhanced Functionality	Self-diagnostics Display
	LS and SOL Number and Condition Alarm Display
	Alarm History of Last 200 Events
	Maintenance Advise Display
	Tool Management on the Tool Detail Screen

GI (Geometric Intelligence) is Makino's high-speed machining technology that addresses the problem of machining complex geometries at high feedrates. GI control corrects servo 'droop' and analyzes and corrects axis acceleration and deceleration, virtually eliminates part gouging caused by the tool violating the program path. This combination of digital servo systems and proprietary software allow machining at feeds up to ten times faster than standard CNC systems. Servo systems operate at maximum performance as GI software optimizes the feedrate-to-tool path and sends readable data directly to the drives.

SGI (Super Geometric Intelligence), also a Makino technology, is based on the GI control software. SGI (option) provides enhanced capabilities, like improved processing of small NC data blocks. SGI is especially effective for machining 3-D shapes of molds and dies involving continuous execution of minute blocks under 1mm (0.040").

In effect, these features allow the user to program the required "feedrate-to-spindle speed ratio" and let GI or SGI control the feedrate based on the part geometry. Feed forward look ahead "smooths" the acceleration and deceleration of the axes on approach to different part details. This "smoothing" produces higher average feedrates, better accuracies, reduced machining time and costs, and improved finishes.

2.3.3 Machine Communications

Feature	Detail
RBU (Remote Buffer Unit)	Standard
Memory Capacity	2,000 Characters / 16.6 ft
Software Interface	Protocol A, B
I/O Communication Ports	RS-232
	Baud Rate – 50 to 19,200
	Maximum Cable Length – 330ft at 4,800 baud and 150 ft at 9,600 baud
	RS-422
	Baud Rate – 50 to 86,400
	Maximum Cable Length – 2,600 ft at 9,600 baud and 150 ft at 19,200 baud
Compatible formats	FS-15M
EIA/ISO Recognition	Automatic

Three dimensional programs can easily exceed millions of characters. Due to file size of these programs it is essential to either, “drip feed” programs to the control with an external memory device (i.e. a PC (Personal Computer)) or use a high-speed DNC (Direct Numerical Control) system for data transfer. A minimum communications speed of 48.8K baud rate (4,880 characters per second) should be used.

The baud rate is affected by the transfer speed of the host computer. Approximate conversion for CPS (Characters Per Second) is baud rate divided by 10.

Shielded Cable Only – signals subject to both high frequency or high voltage interference.

2.3.4 Maintenance and Safety

Feature	Detail
Maintenance and Safety	Emergency Stop
	Axis Overtravel Protection
	Software Interlocks
	Self-diagnostics – CNC and Custom side
	Alarm History – CNC and Custom side
	Help Function – CNC and Custom side

2.3.5 Controlled Axes and Coordinate Systems

Feature	Detail
Controlled Axes	Number of Axis – 3 (up to 5 axes optional)
	Simultaneous Control – 3
Coordinate Systems	Absolute or Incremental – G90- G91
	Automatic Return to Reference Point – Manual or program code – G28
	Reference Point Return Check – G27
	Return From Reference Point – G29
	Return To 2nd Reference Point – G30
	Machine Coordinate System Setting – G53
	Work Coordinate System Selection – G54–G59
	Coordinate System Setting – G92
	Work Coordinate System Preset – G92.1
	Local Coordinate System Setting – G52

2.3.6 Programming

Feature	Detail
Storage	Memory – 31,680 characters or 80 meters (264’) of tape.
	Number of registrable programs – 63
Methods	Standard CNC Language
	Minimum Input Increment – 0.001 mm (0.0001”)
	Maximum Programmable Increment – ±8 digits ±99999.999 mm (±9999.9999”)
	Subprogramming – 4-Folds Nested
	Programmable data input – G10
	Custom Macro B with 82 common variables
	Decimal Point Programming
	Calculator-type Decimal Point Input
Editing	Part program editing
	Background editing
	Program number search
	Sequence number search
	Address and word search
	Part program collation and stop
M, S, and T Functions	S Codes (Spindle Command) 5-digit Address – Sxxxxx
	T Codes (Tool Command) 4-digit Address – Txxxx
	M Codes (Miscellaneous Function) 3-digit Address – Mxxx
Programming Support Functions	Inch or metric selection – G20-G21
	Circular Interpolation – by I, J, K, or radius R programming
	Canned cycles –
	Exact stop check – G09
	Exact stop check mode – G61
	Tapping mode – G63
	Cutting mode – G64

2.3.7 Tool Offsets

Feature	Detail
Tool Offsets	Tool Length Offset – G43, G44, and G49
	Tool Radius Offset C – G41, G42, and G40
	Number Of Tool Offsets – 99
	Tool Offset Memory – Type A

2.3.8 Operational Support

Feature	Detail
Operation Support Functions	Label Skip
	Control In/Out
	Single Block
	Program Stop – M00
	Optional Stop – M01
	Optional Block Skip – / (forward slash)
	Dry Run
	Machine Lock
	Z-axis Feed Cancel
	Auxiliary Function Lock
	Mirror Image – Manual or Program code (M21, M22, M23)
	Manual Absolute
	Program Restart
	Tool Length Measurement – Manual Standard
	Data Protection Key – Memory Protect Key Standard
	Follow-up
	Manual Return to Reference Point

2.3.9 Compensation Functions

Feature	Detail
Control Compensation Functions	Stored Pitch Error Compensation
	Backlash Compensation
	Friction Compensation – for GI motion control
	Feed Forward Look Ahead – for GI motion control
	Unidirectional Positioning – G50

2.3.10 Interpolation and Feeds

Feature	Detail
Interpolation	Rapid Positioning – Manual and program code G00
	Linear Interpolation – Manual and program code G01
	Circular Interpolation – G02 (CW) - G03 (CCW)
Feeds	Cutting Feedrate – F address – Fxxx.xx
	Dwell – G04
Axis Motion Overrides	Manual Rapid-Traverse Override – min. 25, 50, 100%
	Manual Cutting Feedrate Override – 0 to 200%
	Programmable Feedrate Override Cancel – M49-M48

2.4 Installation Information

This section contains information on machine size, electrical power, and air pressure specifications required by the machining center.

2.4.1 Machine Size

Machine dimensions are listed in Table 2-9 and shown in Figure 2-6.

- External dimensions and floor plans are presented in section 2.5 (pg 2-23).

TABLE 2-9 MACHINE DIMENSIONS

Item	Specification	(approx. US)
Height	3,113 mm	(122.6")
Width, 25 Tool ATC	2,800 mm	(110.2")
Width, 40 or 80 Tool ATC	2,700 mm	(106.3")
Depth	3,140 mm †	(123.6")
Weight [including CNC unit]	9,300 kg	(20,503 lb)
Leveling Method	3-Point Support; 2 Supports Adjustable	
Transportation Dimensions		
Height	2,745 mm	(108")
Width, 25 Tool ATC Without APC	2,470 mm	(97.2")
Width, 25 Tool ATC With APC	2,592 mm	(102")
Width, 40 or 80 Tool ATC Without APC	2,440 mm	(96")
Width, 40 or 80 Tool ATC With APC	2,562 mm	(100.9")
Depth	3,090 mm	(121.6")
† Plus room at rear, right side, near MTC for a transformer 622 × 465mm (24.5 × 18.3") - North America Only.		

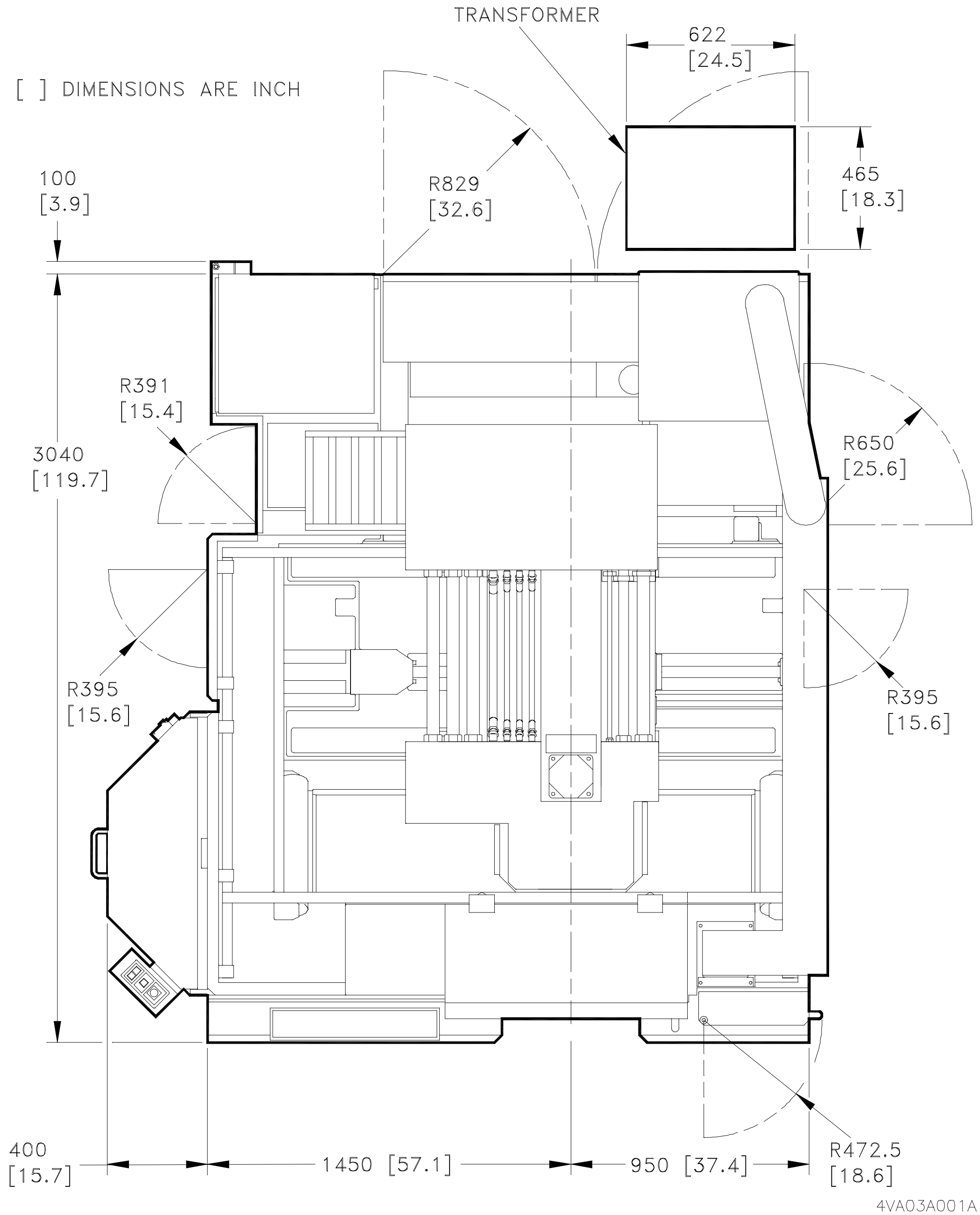


FIGURE 2-6 FLOOR SPACE FOR STANDARD MACHINE

2.4.2 Electrical Power

A 3-phase power source, with stable voltage regulation (±10%) and a ground of 100 ohms or less, must be provided. A step down transformer is provided to help regulate voltage and allow for different voltages.

The V55 is set up to run on 200/220 VAC, 55 kVa, 50/60 Hz ±2% off the secondary side of the transformer. Secondary voltage output is connected to a terminal point in the MTC.

- Provide a properly sized service box for the machine. Use local code and Table 2-10 to assist in sizing the machine's electrical service. Use the machine kVa rating when calculating machine electrical consumption.
- Ensure the electrical service voltages meet all requirements; 200/220 VAC (±10%), 75 kVa, 50/60 Hz, and a proper earth ground (100 ohms or less) is provided.
- If the required voltage cannot be maintained within ±10%, an additional automatic voltage regulator must be installed.
- Connect incoming electrical service to the machining center Main Power switch, as described in the Pre-Installation Guide.

TABLE 2-10 MACHINE POWER REQUIREMENTS

To convert kVa to amperage for service amperage:

$$\frac{kVa \times 1000}{1.73 \times Voltage} = amps$$

then take:

amps × 125% = Service

Power Requirements		
	14,000 rpm	**20,000 rpm**
Machine kVa Rating	55 kVa	65 kVa
Source Voltage	200–480V [±10%]	200–480V [±10%]
Operating Voltage	200–220V [±10%]	200–220V [±10%]
Cycle	50/60Hz [±2%]	50/60Hz [±2%]

2.4.3 Transformer Specification

An additional transformer is provided for machines in different countries.

DANGER

Do Not Turn Power ON!

Make Connections only. All connections and settings must be confirmed by a Makino service representative, prior to applying power.

North America

The North American transformer is an external, stand-alone, floor type that can be located within a six-foot radius of the MTC. Specifications for the transformer are presented in Table 2-11. Refer to the Pre-Installation Guide for more detail.

TABLE 2-11 TRANSFORMER SPECIFICATION

Transformer Specification		
Manufacturer	NORLAKE Specialty Transformers	
Rating	65 kVa	
Type	3-phase	
Cycle	60 Hz	
Primary Voltage	230 - 460 Delta	
Secondary Voltage	208 Delta	
Type	Electrostatic Shield	
Taps	2-2 1/2% AN and BN	
Wire Type	Copper	
Enclosure	Floor Mount	
Manufacturer Number	ST-3361	
Makino Number	E18530-00	
Weight	239 kg	527 lb
Necessary jumpers for dual primary voltage to be supplied by transformer manufacturer.		

2.4.4 Air Pressure Source

Because air is used in and around the spindle area, contamination of the bearings or other components by dirt or moisture in the air delivery system could cause premature component wear and failure.

Makino recommends you have your air delivery system checked for dirt and moisture at or near the machining center's point of connection. Add additional filters or water traps, as required.

- The air supply should be permanently piped when the final site is determined.

Table 2-12 lists air specifications for the V55.

TABLE 2-12 AIR PRESSURE SPECIFICATIONS

Item	Specification	(approx. US)
Pressure, Minimum	0.5 Mpa	(72.5 psi)
Consumption [Volume at atmospheric pressure]	600 L/min	(21.2 ft^3/min)
Limitations		
Supplied air supply to the air drier or machining center must not exceed 40% relative humidity. Air conditioned air must be dry, clean, and cool.		

2.5 External Dimensions and Floor Plans

This section provides external dimensions and floor plan drawings to ensure proper site selection for the machining center.

Position with sufficient clearance to:

- Access the rear of the machine and all auxiliary components.
- Completely open all cabinet doors and panels.
- Prevent interference and potential pinch points of moving components with structural features (pillars, walls, etc.), other machines, their range of movement, or other components.

Proposed floor plans and external dimensions for machines with various optional features are shown in the following figures:

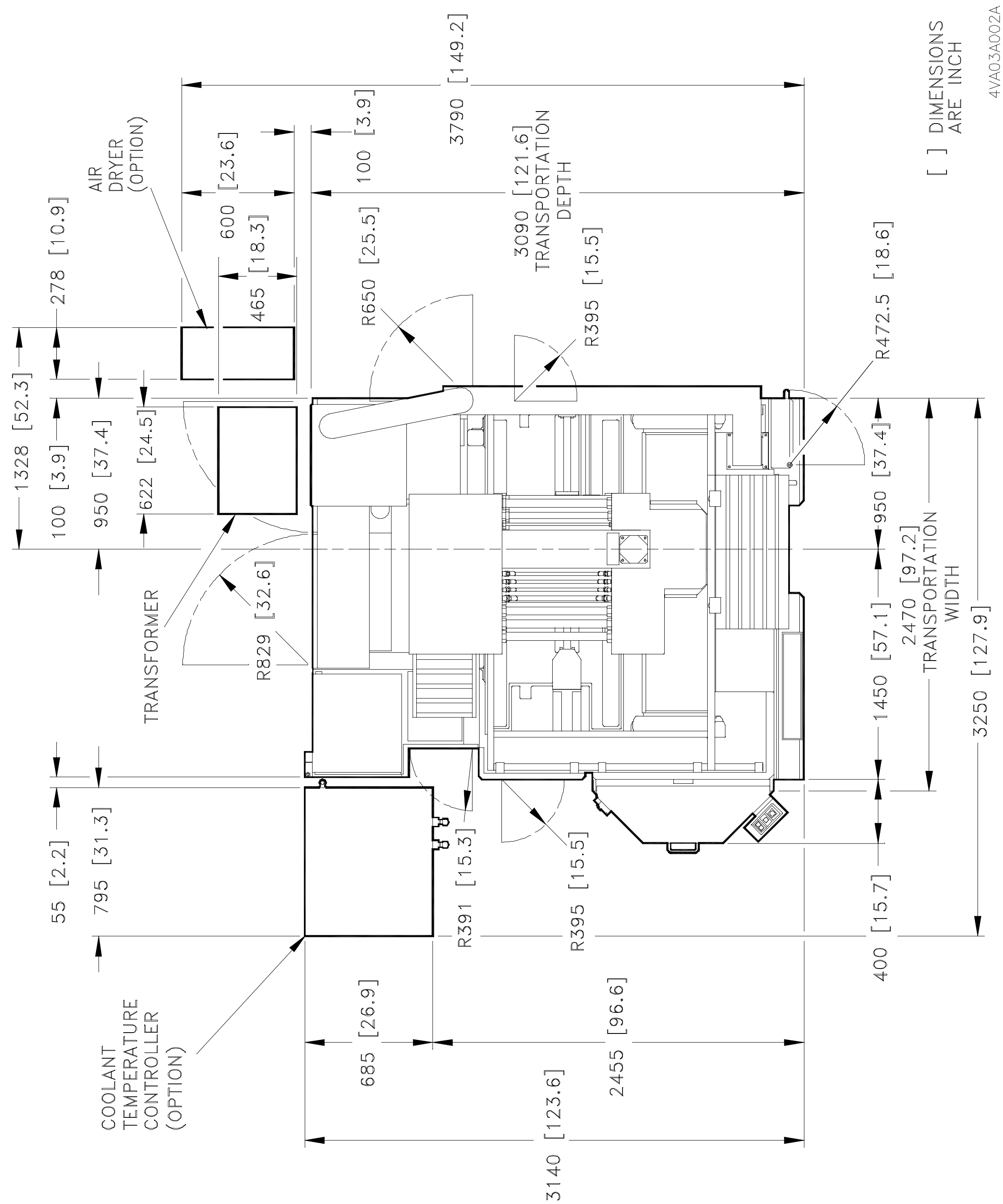


FIGURE 2-7 V55 WITH 25-TOOL ATC

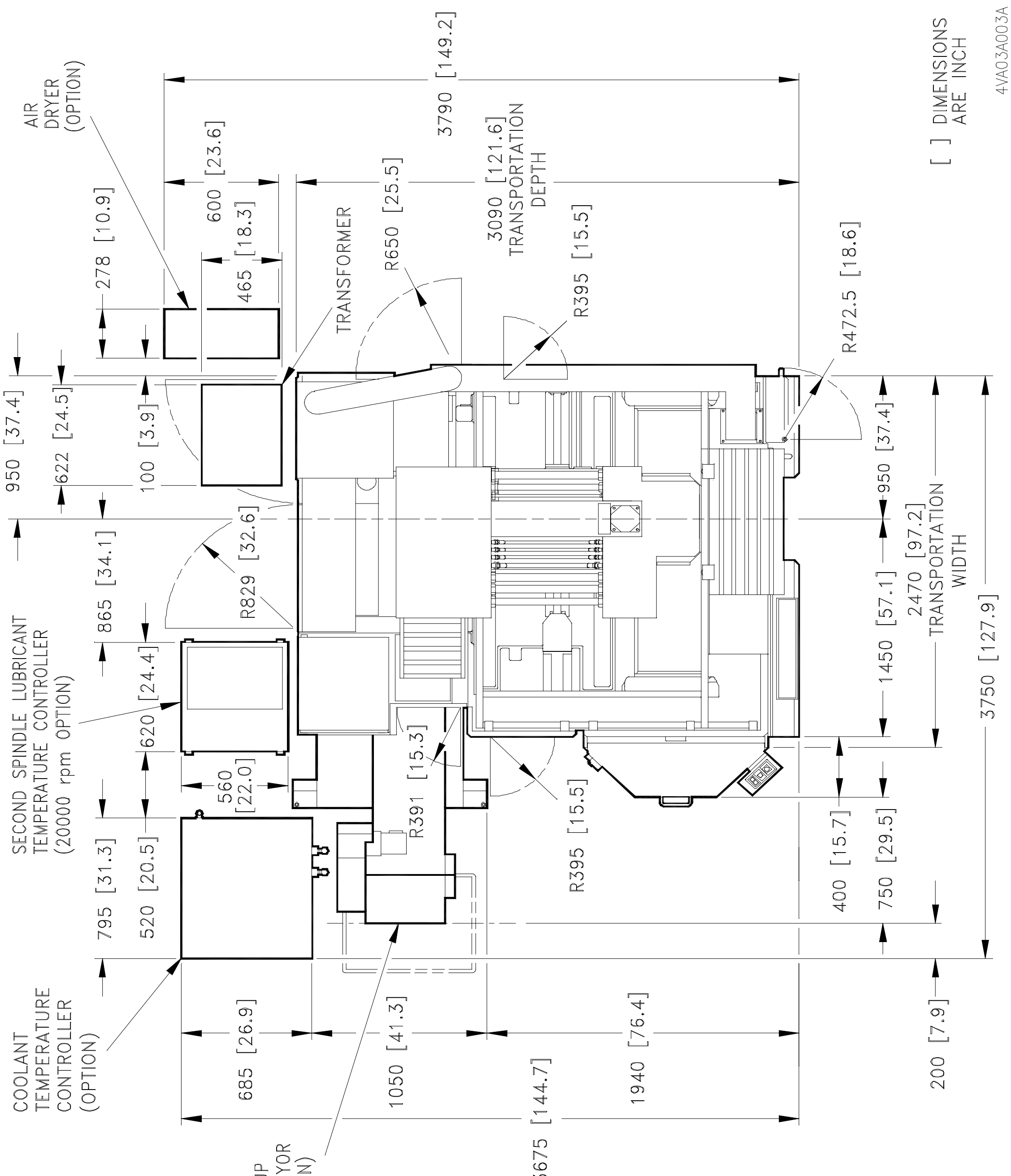


FIGURE 2-8 V55 WITH 25-TOOL ATC AND LIFT-UP CHIP CONVEYOR (LEFT)

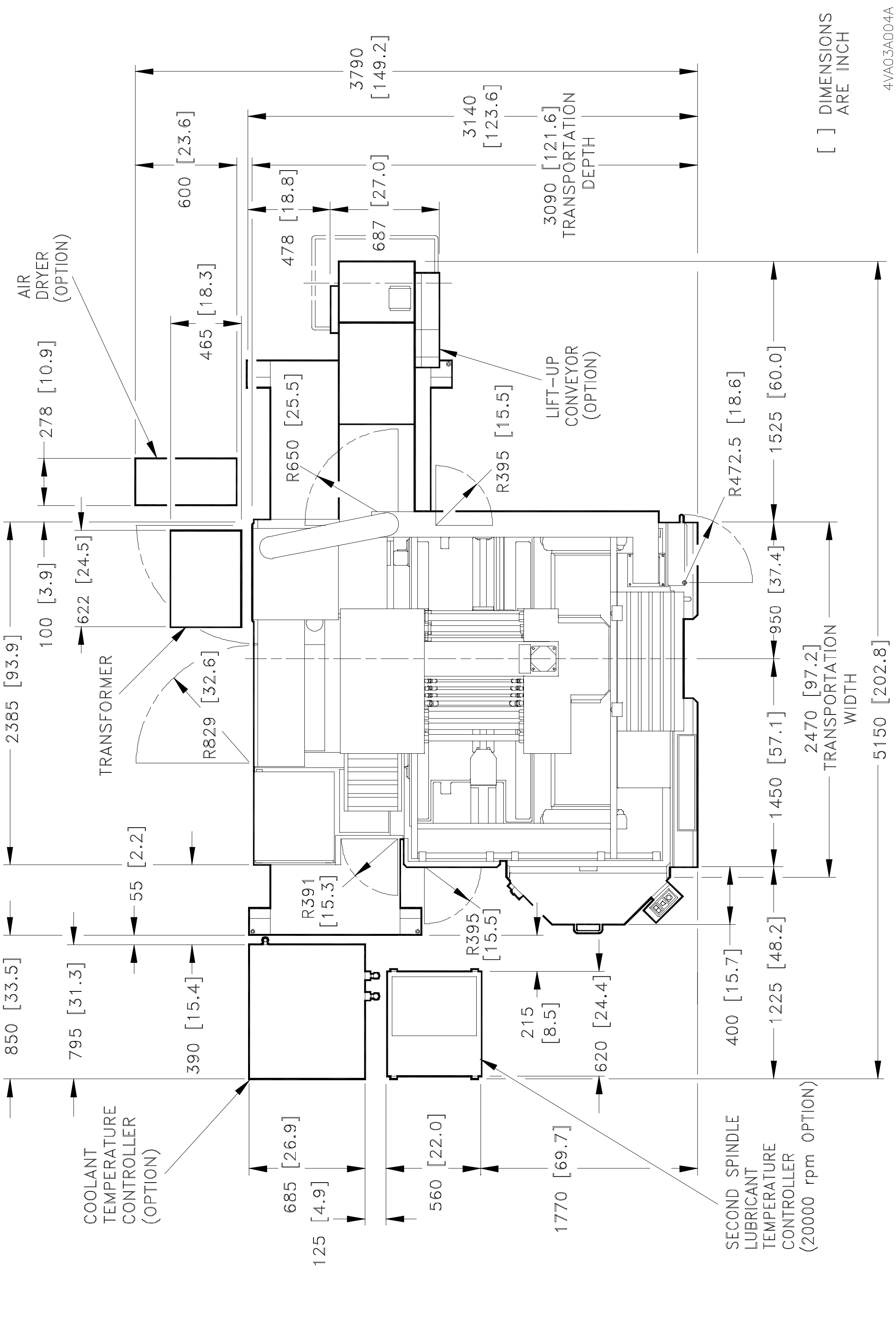


FIGURE 2-9 V55 WITH 25-TOOL ATC AND LIFT-UP CHIP CONVEYOR (RIGHT)

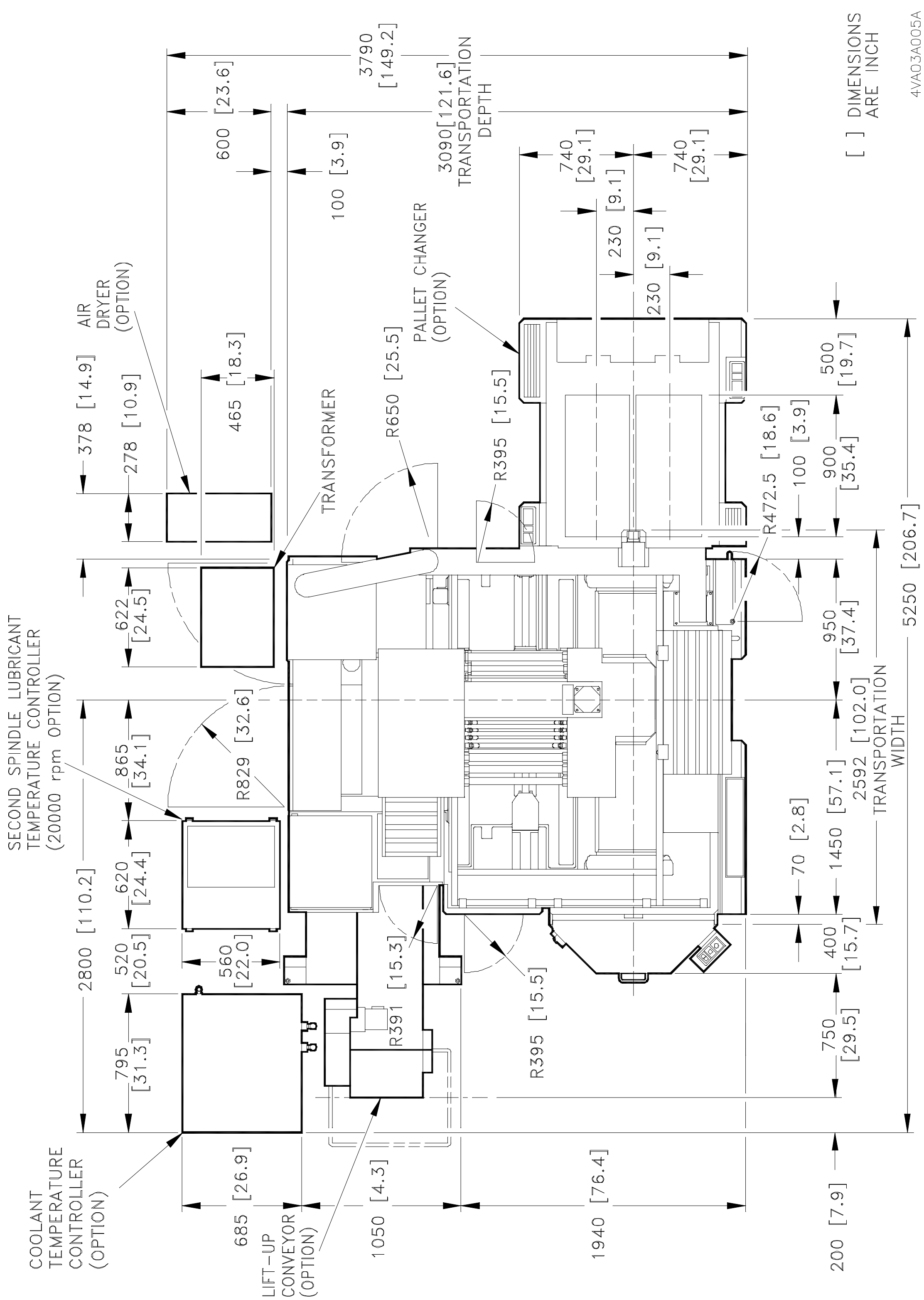


FIGURE 2-10 V55 WITH 25-TOOL ATC, LIFT-UP CHIP CONVEYOR (LEFT) AND APC

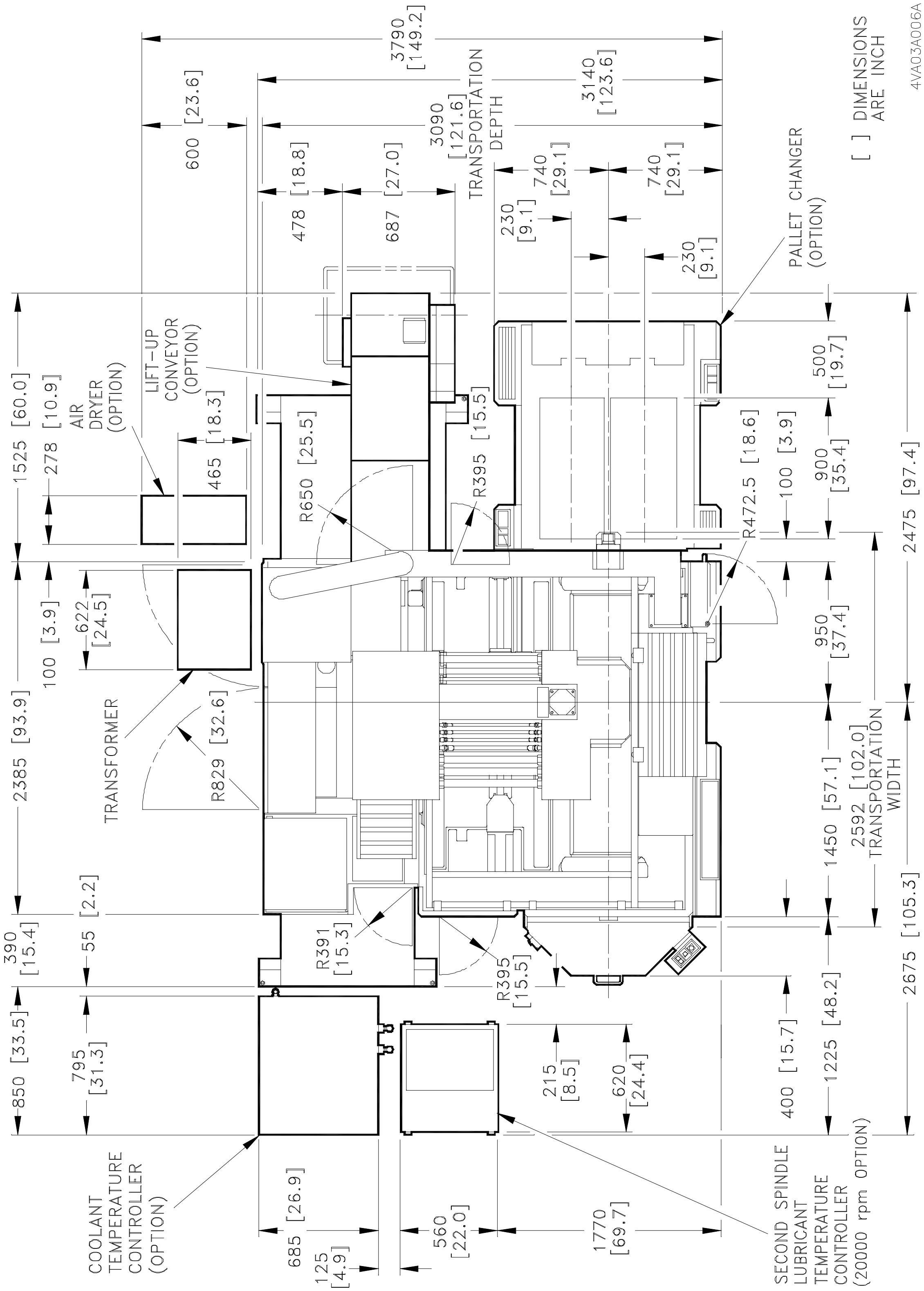


FIGURE 2-11 V55 WITH 25-TOOL ATC, LIFT-UP CHIP CONVEYOR (RIGHT), AND APC

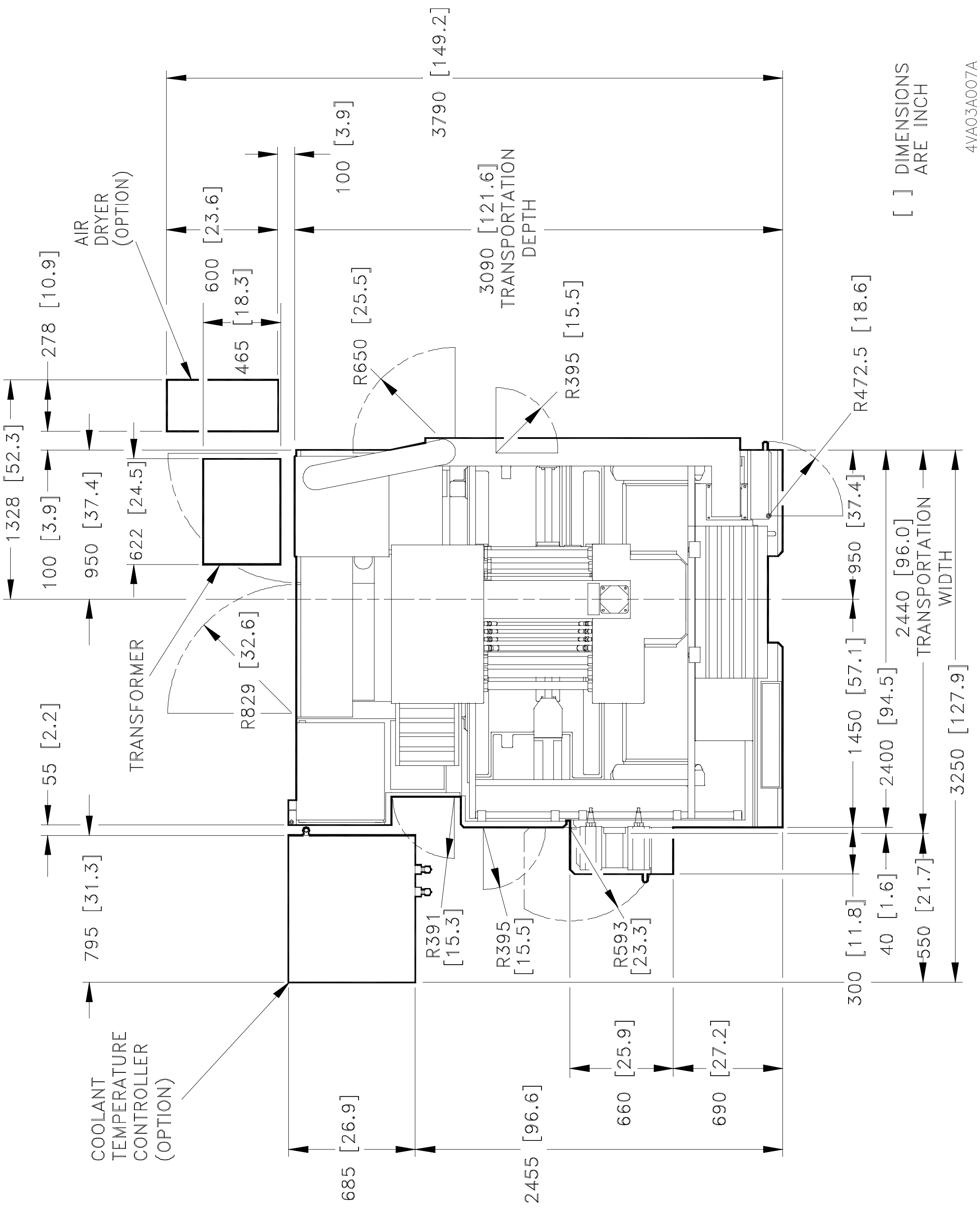


FIGURE 2-12 V55 WITH 40 OR 80-TOOL ATC

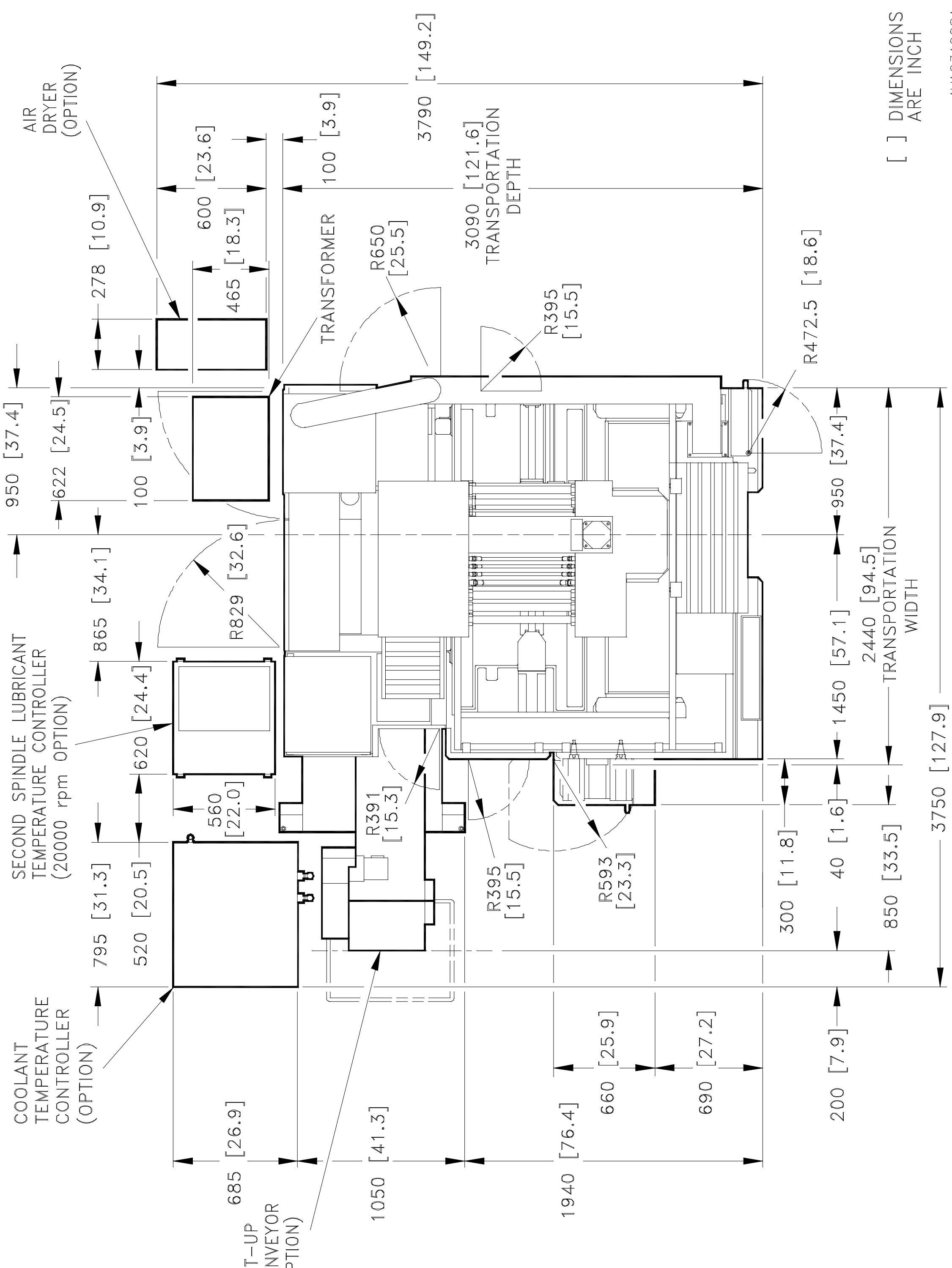


FIGURE 2-13 V55 WITH 40 OR 80-TOOL ATC AND LIFT-UP CHIP CONVEYOR (LEFT)

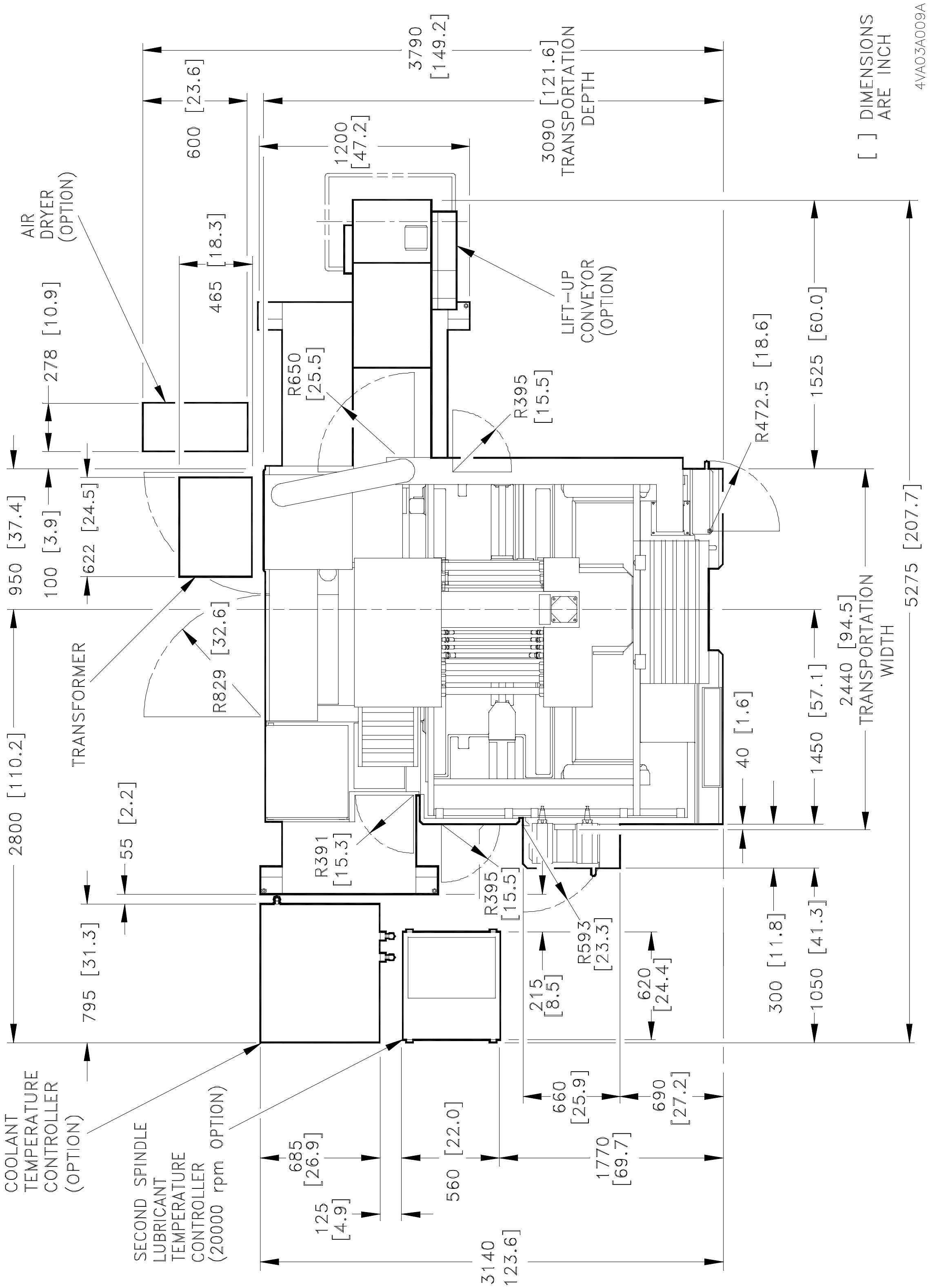


FIGURE 2-14 V55 WITH 40 OR 80-TOOL ATC AND LIFT-UP CHIP CONVEYOR (RIGHT)

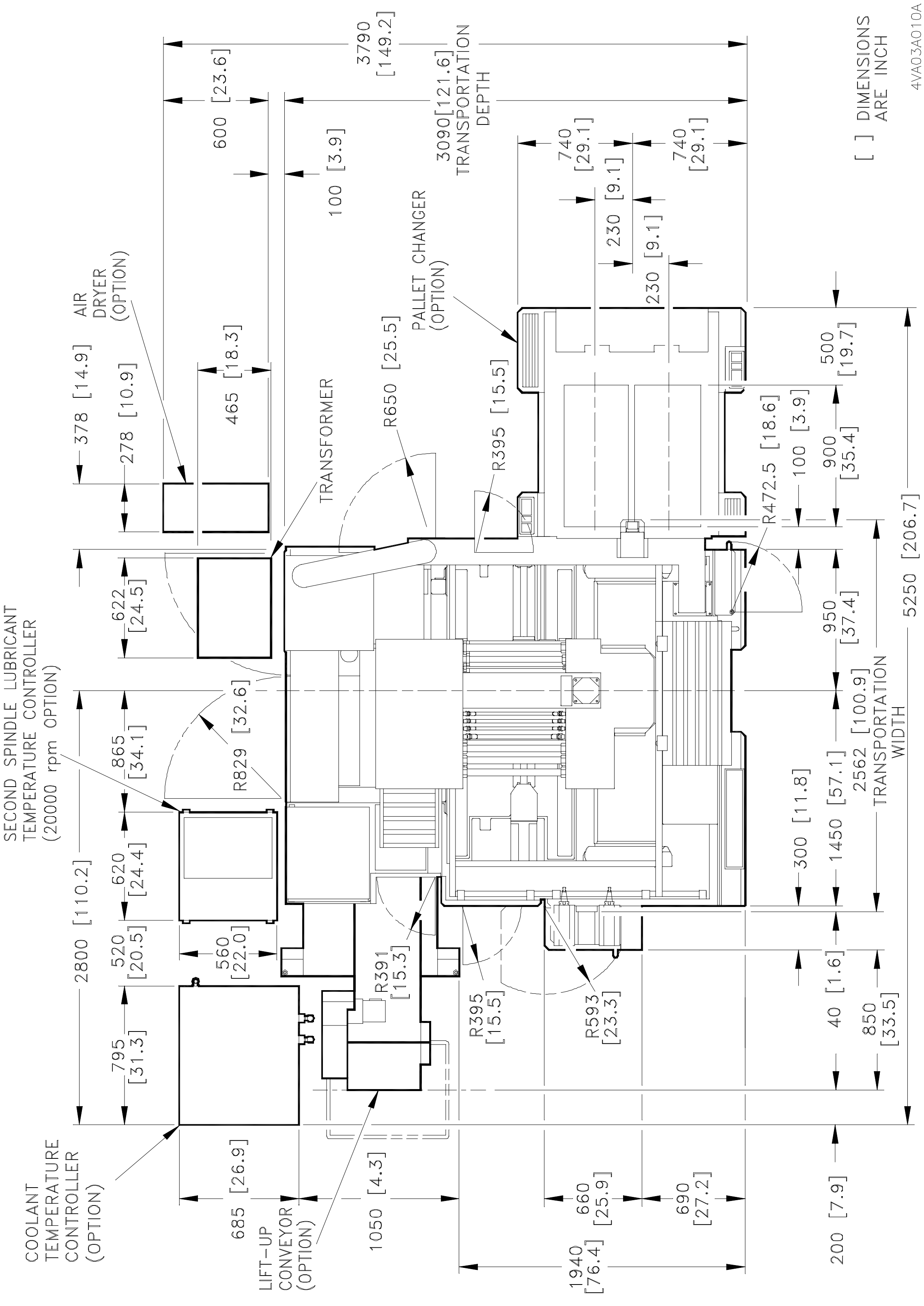


FIGURE 2-15 V55 WITH 40 OR 80-TOOL ATC, LIFT-UP CHIP CONVEYOR (LEFT), AND APC

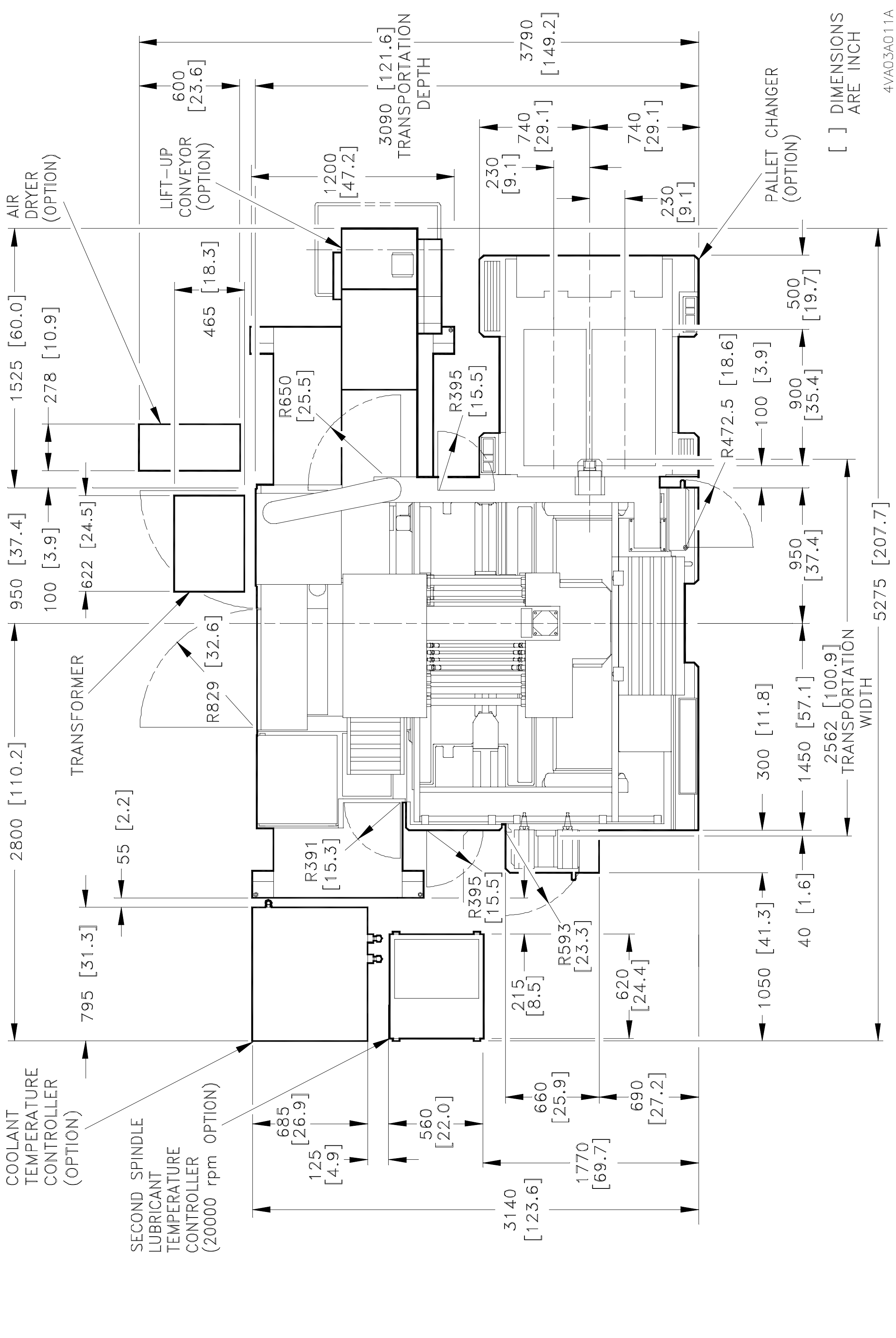


FIGURE 2-16 V55 WITH 40 OR 80-TOOL ATC, LIFT-UP CHIP CONVEYOR (RIGHT), AND APC

NOTES:

SKETCHES:

Chapter 3 Preventive Maintenance

Makino V55 High-speed Vertical
Machining Center

MAKINO

Chapter 3
Preventive Maintenance

Contents

3.1 Overview

This chapter presents information on the recommended schedule for routine maintenance and lubrication and Preventive Maintenance (PM) schedule for the V55 Vertical Machining Center with Makino Professional (PRO) 3 control.

The importance of periodic maintenance and lubrication for any piece of equipment cannot be over emphasized. Makino strongly suggests implementing a PM (Preventive Maintenance) program from day one of the machine installation.

Such a program not only assures; that the machine is operating safely and at peak performance, but also significantly increases the life of the machine tool, while reducing unplanned downtime.

Machine Configuration

The information provided in this chapter is for a standard machine and common optional configurations. Additional optional configurations may change or add PM tasks. Refer to the specific documentation provided with those options and adjust your PM program accordingly.

3.2 Lubricants

Makino machining centers are built to exacting design specifications to produce machine tools capable of maintaining the dependability, precision and accuracy's demanded by today's standards. Using the correct lubricants and properly maintaining their delivery systems are a key factor in achieving these requirements.

3.2.1 Oils

The V55 components using lubricating oils include: the Oil Controller and the Hydraulic System.

The **Oil Controller** - uses Makino Spindle Luricant to lubricate the spindle and ball screw TAC bearings; and for cooling the spindle, ball screws, and other machine components.

The **Hydraulic System** - uses oil to provide hydraulic pressure for operation of the spindle unclamp mechanism.

Table 3-1 (pg. 3-5) lists the Makino recommended oils for the V55.

3.2.1.1 Guidelines for Oil Systems

Practice these guidelines with any lubrication system.

CAUTION

Never Mix Oils Of Different Types, Grades Or Manufacturer

This may result in a chemical reaction that can damage the oil system and/or related parts.

- Make certain that all cans, funnels, hoses, etc. are clean and free of chips and other contaminants.
- Set up a PM schedule for changing oils and filters and cleaning reservoirs to reduce component failure caused by thermal breakdown of the oil.

In all cases, if oils other than those provided with the machine are used:

- Drain the "old" oil and clean the system before using the "new" oil.
- Be sure that the replacement oil is of the same viscosity, as the supplied oil. Using oil of different viscosity affects the system running temperature, load, and pressure promoting wear and premature failure of system components.
- Makino recommends using our listed oils only. Tests have proven these oils to be superior pertaining to the machine tool and its performance.
- Oils listed in other documents provided with the machine are cross-referenced oils. The use of cross-referenced oils will affect machine performance and /or accuracy.

3.2.2 Greases

Never Mix Petroleum Grease With Silicone Grease
Never Mix Grease Containing Different Base Compositions

CAUTION

These greases are incompatible and may result in an undesirable chemical reaction causing premature failure of components.

The V55 components using lubricating grease include: the X, Y, and Z axes ball nuts and LM (Linear Motion) guide way systems.

X, Y, and Z Axes Ball Nuts - are grease lubricated, manually from two central sources or automatically from the optional, cartridge type, Automatic Grease Supply Unit.

X, Y, and Z Axes LM Guides - are grease lubricated, manually from two central sources or automatically from the optional, cartridge type, Automatic Grease Supply Unit.

Table 3-1 (pg. 3-5) lists the Makino recommended greases for the V55.

3.2.2.1 Guidelines for Grease Lubricated Systems

Practice these guidelines with any grease type lubrication system.

- Keep grease clean and free of contaminates.
- Clean all grease fittings before apply grease gun.
- Do not over-grease components. This can cause undesirable heat build up and premature failure.
- Lubricate motors at a standstill. Remove and replace caps and/or drain plugs with the motor at a standstill.

3.2.3 Makino Recommended Lubricants

Table 3-1 lists both the oils and greases recommended by Makino for use on the V55 and are supplied with the machine. Using other oils or greases may result in damage to the machine tool or its components.

Regular oil changes and cleaning of the reservoirs keeps lacquer build-up to a minimum and reduces component failure.

TABLE 3-1 MAKINO RECOMMENDED LUBRICANTS

Supply Point	Lube Type	Manufacturer	Name
Hydraulics	Oil	Shell	Tellus 32
Oil Controller	Oil	Makino	Spindle Lubricant[1]
Ball Nuts	Grease	Kluber	Isoflex NBU 15
LM Guides	Grease	Kluber	Isoflex NBU 15

1 No recommended substitute.
2 Automatic Lube Unit (option) see section 3.2.3.1

3.2.3.1 Automatic Lube

The Automatic Lube (option) automatically lubricates the X, Y, and Z axes ball nuts and LM guides at specific intervals. This unit uses a grease cartridge and is equipped with a limit switch to generate an alarm when the cartridge needs replaced.

Recommended Grease Cartridge:

Unilub DL No2T Grease

- Replacement cartridges are available from Makino; part number GKL-2-050

3.3 Lubrication Breakout Chart

Table 3-2 (pg. 3-8) provides detail for units requiring oil lubrication. Use Figure 3-1 for the locations of related fill and drain ports.

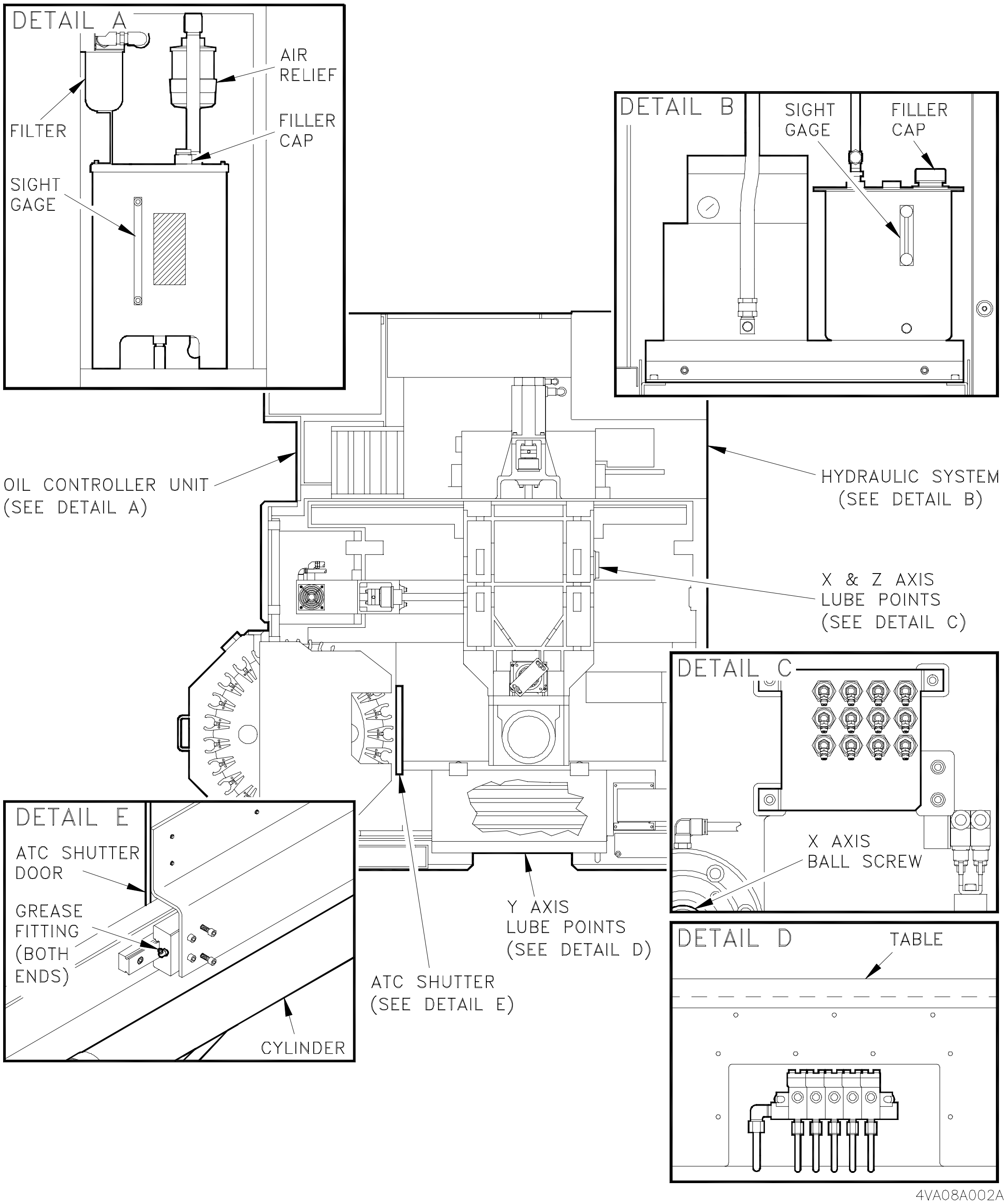


FIGURE 3-1 LUBRICATION BREAKOUT DRAWING

TABLE 3-2 LUBRICATION BREAKOUT CHART

Hydraulic Tank - See Detail B - Figure 3-1	
Inspection Point	Sight glass on reservoir.
Oil Level	Keep level full in sight glass.
Frequency	Inspect daily, add oil as necessary. Change every 2000 hours of operation.
Quantity	10 liters (2.6 gallons)
Lubricant	Shell Tellus 32
Method	**TO TOP OFF OIL:** Remove the fill cap and top of the reservoir. Add oil until oil level meets the full line in the sight glass. **TO DRAIN OIL:** With the machine Off, remove the drain plug at the bottom of the reservoir and allow oil to drain. Replace the plug and fill as described in **TO TOP OFF OIL**.
Oil Controller - See DETAIL A - Figure 3-1	
Inspection Point	Sight glass on reservoir.
Oil Level	Keep level full in sight glass.
Frequency	Inspect daily, add oil as necessary. Check oil level with the spindle running. Change every 2000 hours of operation.
Quantity	30 liters (7.9 gallons)
Lubricant	Makino Spindle Oil
Method	**TO TOP OFF OIL:** Remove the fill cap and top of the reservoir. Add oil until oil level meets the full line in the sight glass. **TO DRAIN OIL:** With the machine Off, remove the drain plug at the bottom of the reservoir and allow oil to drain. Replace the plug and fill as described in **TO TOP OFF OIL**.

[1] Frequency is based on: 40 hours per week, 200 hours per month, 1200 hours semi-annually, and 2000 hours annually.

[2] Dispose of "old oil" according to local, state, and federal regulations.

TABLE 3-2 LUBRICATION BREAKOUT CHART (CONTINUED)

X and Z Axes Ball Nuts - See DETAIL C - Figure 3-1	
Lubrication Point	Grease fittings located on right side of column.
Frequency	Every 1000 hours (6 months) of operation.
Quantity	40cc each ball nut.
Lubricant	Kluber Isoflex NBU 15 grease.10 liters (2.6 gallons)
Method	See chapter 7.
X and Z Axes LM Guides - See DETAIL C - Figure 3-1	
Lubrication Point	Grease fittings located on right side of column.
Frequency	Every 1000 hours (6 months) of operation.
Quantity	32cc - each X axis fitting, 36cc - each Z axis fitting.
Lubricant	Kluber Isoflex NBU 15 grease.
Method	See chapter 7.
Y Axis Ball Nut - See DETAIL D - Figure 3-1	
Lubrication Point	Grease fitting located on front of table.
Frequency	Every 1000 hours (6 months) of operation.
Quantity	40cc each ball nut.
Lubricant	Kluber Isoflex NBU 15 grease.
Method	See chapter 7.
Y Axis LM Guides - See DETAIL D - Figure 3-1	
Lubrication Point	Grease fittings located on front of table.
Frequency	Every 1000 hours (6 months) of operation.
Quantity	32cc - each X axis fitting.
Lubricant	Kluber Isoflex NBU 15 grease.
Method	See chapter 7.
ATC Shutter - See DETAIL E - Figure 3-1	
Lubrication Point	Grease fittings located on shutter LM guides.
Frequency	Every 1000 hours (6 months) of operation.
Quantity	4 cc each fitting.
Lubricant	Kluber Isoflex NBU 15 grease.
Method	See chapter 8.

[1] Frequency is based on: 40 hours per week, 200 hours per month, 1200 hours semi-annually, and 2000 hours annually.

[2] Dispose of "old oil" according to local, state, and federal regulations.

3.4 Preventive Maintenance Schedule

PM (Preventive Maintenance) is the first step in the proper care and maintenance of any piece of equipment. Proper care and maintenance can assure peak machine operation, accuracy, performance, and productivity.

A good PM schedule allows for "planned" down time, which is more convenient than unplanned down time. Additional advantages of an established PM schedule are:

- The materials, tools, and/or parts necessary for the PM tasks can be on hand prior to shutting down the machine.
- Maintenance personnel should be able to complete the PM tasks relatively quickly once they become more familiar with the machine tool.
- Several PM tasks can be performed simultaneously, as they are located in the same area.
- Checks and adjustments listed in the PM schedule keep the machine tool at peak performance. This eliminates many annoying and time consuming machining problems with sizing, chatter, and finish while preventing machine faults due to component failure or wear.
- Performing the PM schedule as provided, takes less than 2% of machine availability for the year.

The PM tasks are presented by performance frequency.

- DON'T underestimate the importance of establishing and following a good PM and Lubrication Schedule.

Service Tip

The following tables provide PM and Lubrication checks on a Daily, Weekly, Monthly, Semi-Annual and Annual basis.
Makino recommends you copy these tables and use them as a PM and Lubrication Schedule for your machine.
Each table provides "blank" rows for you to add PM or Lube tasks that may be specific to your machine.

3.4.1 Initial Checks

Perform these checks three months after installation of the machine tool.

Though performed only once, these tasks are the most important PM items to be performed. It is during the first three months of operation that the initial "break-in" of components occur, possibly leading to problems such as contamination of oil supplies.

During this period the machine "moves" more than at any other time as the machine and foundation stabilize. This affects level and/or head to table tram.

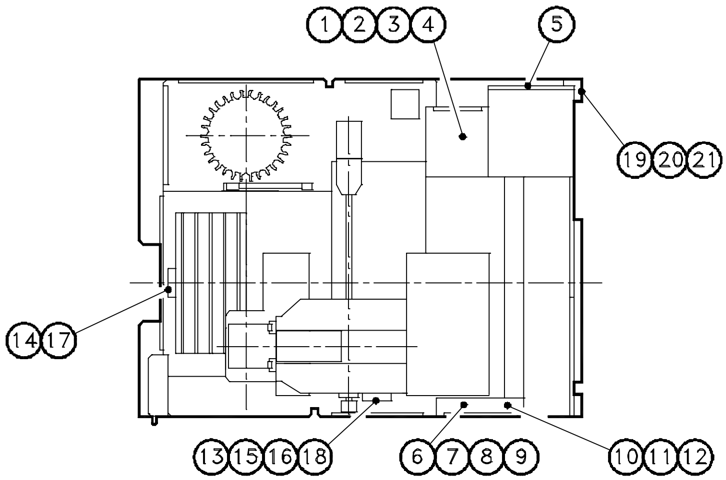
Hydraulic System – Drain and clean the hydraulic tank and refill with new oil.

Machine Level – Check machine level and adjust if necessary, see section 3.5.

3.4.2 Daily Checks

Perform Daily PM checks at the beginning of each shift. These are simple visual checks, performed in a few minutes. Use the Daily Inspection chart (Figure 3-4) mounted on the side of the machine as a guide to component locations.

DAILY INSPECTION



Location	Spindle Oil Temp. Controller					Hydraulic Unit				Air Control Unit			Linear Bearing X-Axis	Linear Bearing Y-Axis	Linear Bearing Z-Axis	Ball Screw X-Axis	Ball Screw Y-Axis	Ball Screw Z-Axis	Coolant Tank		
No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Code / Items			Line Filter	Cleaner	Air Filter				Suction Filter		0.01u	5u								Punching Filter	Mesh Filter
Inspection	1 Day					1 Day		1 Day		1 Day									1 Day		
Supply (h)													1000	1000	1000	1000	1000	1000			
Clean (h)					50				2000											50	50
Change (h)		2000	*	2000			2000				2000	2000							2000		
Lubricant	Makino Spindle Lubricant					Shell Tellus Oil 32				——			With Auto Grease Lub Without Auto Grease Lub			UniLub DL-NO.2T Grease Mobil Grease 22 Kluber Isoflex NBU 15			——		
Tank Cap. (ℓ)	30					10				——			——	——	——	——	——	——	※		
Volume (cc)	——					——				——			32	32	36	40	40	40	——		
Supply Method	Drain completely using plug at bottom of spindle oil temperature controller tank. Remove filter cap, and fill to high limit of level gauge. (Check gauge when spindle is operating.) Make sure to replace cap after filling. *Replace filter element when line filter switch (LS173) activates.					Drain all oil. Fill to high limit of level gauge.		Normal 7Mpa		Normal 0.5Mpa			Replenish grease at grease nipples using a grease gun. X, Z-axis nipples accessed through right-side door. Y-axis nipples accessed through table front cover. For machines with automatic grease supply, replace grease cartridge (GKL-2-050) when automatic grease supply switch (LS1698) activates. Replace grease cartridge through left-side door.						20 21 applicable for chip bucket-type only. ※ Chip bucket type 550 ℓ Chip conveyor type 670 ℓ		

Notes:
1. Clean the location to be lubricated and inlet before performing lubrication.
2. Use containers designed especially for lubricating to prevent the entrance of foreign matter.
3. The type of lubricant used has an influence on the accuracy and performance of the machine. When changing lubricant types, please consult Makino.
4. The maintenance intervals have been calculated using an average operating time of 8 hours per day. If the operating time is less than this, use the following chart to calculate maintenance interval.

Hours (h)	50	200	1000	2000
Interval	1 week	1 month	6 months	1 year

5. Refer to the maintenance manual for items not described in this chart.

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FIGURE 3-4 DAILY INSPECTION CHART

TABLE 3-3 DAILY PM CHECKS (SHEET 1 OF 2)

Daily PM Checks	Checked		Action
	By	Date	
GENERAL CHECKS			
1. Clean dirt, dust, and chips off the tapered shank of all tooling.			
2. Clear all obstacles from around or within the range of machine movement.			
3. Listen for air leaks. Have leaks repaired immediately.			
HYDRAULIC SYSTEM			
1. Check the oil level of the reservoir. Add as needed. †			
2. Check system pressure. Pressure should be 7MPa (1017 psi).			
OIL CONTROLLER UNIT			
1. Check the oil level of the reservoir. Add as needed. †			
SPINDLE HEAD			
1. Clean the spindle taper, using the spindle taper cleaning tool.			
† Adding oil on a regular basis, indicates a leak. Have the system inspected for leaks and repaired.			

TABLE 3-3 DAILY PM CHECKS (SHEET 2 OF 2)

Daily PM Checks	Checked		Action
	By	Date	
COOLANT UNIT			
1. Check coolant level and concentration. Add as necessary.			
2. Clean the chip pan of chips			
MAIN AIR SUPPLY (FR UNIT)			
1. Check air pressure. Air pressure should be 0.5 MPa (70 psi)			
AIR DRYER			
1. The air temperature should be 50° C (122° F) or less.			

3.4.3 Weekly Checks

TABLE 3-4 WEEKLY PM CHECKS

Weekly PM Checks	Checked		Action
	By	Date	
GENERAL CHECKS			
1. Perform all listed Daily checks.			
OIL CONTROLLER			
1. Perform all listed Daily checks.			
2. Clean the air filter.			
MAIN AIR SUPPLY			
1. Inspect incoming air hose for cuts and leaks. Remove any embedded metal chips.			

3.4.4 Monthly Checks

TABLE 3-5 MONTHLY PM CHECKS

Monthly PM Checks	Checked		Action
	By	Date	
GENERAL CHECKS			
1. Perform all listed Daily checks.			
2. Perform all listed Weekly checks.			
MAIN POWER SWITCH			
Check operation of Main Power switch: 1. Turn the Main Power Switch Off. 2. Turn the Main Power Switch On, confirming power indicator lamp turns ON. 3. Press the [TEST] button (on switch body). Confirm Main Power switch trips and power indicator lamp turns Off. 4. Turn Main Power switch to Off, wait one minute and set to On.			
CHIP SCRAPER			
1. Check and adjust chain tension, as necessary.			
2. Verify that chain is aligned properly and not jumped a tooth on a gear.			
3. Lubricate chain. Brush chain with a general purpose oil.			
LIFT-UP CHIP CONVEYOR (Refer to manufacturer's documentation for details)			
1. Check and adjust chain tension, as necessary.			
2. Clean motor air intake.			
3. Lubricate motor and conveyor			

3.4.5 Semi-Annual (1000 Hour) Checks

TABLE 3-6 SEMI-ANNUAL PM CHECKS (SHEET 1 OF 2)

Semi-annual PM Checks	Checked		Action
	By	Date	
GENERAL CHECKS			
1. Perform all listed Daily checks.			
2. Perform all listed Weekly checks.			
3. Perform all listed Monthly checks.			
4. Inspect all piping, connections, actuators, etc. for leaks. Correct as required.			
X, Y, AND Z BALL NUTS			
1. Lubricate the X, Y, and Z axes ball nuts. See chapter 7.			
X, Y, AND Z LM GUIDES			
1. Lubricate the X, Y, and Z axes LM Guides. See chapter 7.			
MACHINE COVERS AND DOORS			
1. Y axis telescopic covers - Thoroughly clean. Check for damage and smooth operation.			
2. X axis roll-up covers - Thoroughly clean. Check for damage and smooth operation. Check and adjust tensioner mechanism.			
3. Rolling S/G door - clean door and opening. Check for damage Verify smooth operation and proper operation of Safety Interlock.			
4. Lubricate motor and conveyor			

TABLE 3-6 SEMI-ANNUAL PM CHECKS (SHEET 2 OF 2)

Semi-annual PM Checks	Checked		Action
	By	Date	
5. ATC shutter door - Clean door and opening. Check for damage and proper operation. Adjust positioning rate and cushioning, as necessary			
MACHINE LEVEL AND ALIGNMENTS			
1. Check machine level, adjust as necessary.			
2. Check spindle-to-table squareness, see chapter 6.			
MOTORS			
1. Clean air intake on all air cooled motors.			
2. Lubricate all motors in accordance with the manufacturers specifications.			

3.4.6 Annual (2000 Hour) Checks

TABLE 3-7 ANNUAL PM CHECKS (SHEET 1 OF 2)

Annual PM Checks	Checked		Action
	By	Date	
GENERAL CHECKS			
1. Perform all listed Daily checks.			
2. Perform all listed Weekly checks.			
3. Perform all listed Monthly checks.			
4. Perform all listed Semi-Annual checks.			
5. Inspect all covers, cables, and hoses for wear and proper working condition.			
6. Check operating voltages			
HYDRAULIC SYSTEM			
1. Drain old oil, clean reservoir, refill with new oil.			
OIL CONTROLLER			
1. Drain old oil, clean reservoir, refill with new oil.			
AIR CONTROL UNIT			
1. Clean water trap.			
2. Replace filter element.			
X, Y, Z LM GUIDES			
1. Inspect all LM guide rails for wear.			
2. Inspect all LM guide block seals for wear and excessive leakage.			

TABLE 3-7 ANNUAL PM CHECKS (SHEET 2 OF 2)

Annual PM Checks	Checked		Action
	By	Date	
MACHINE LEVEL AND ALIGNMENTS			
1. Check machine level, adjust as necessary.			
MACHINE ALIGNMENTS			
1. Perform the Backlash Measurement procedure and, if necessary, adjust Parameter 1851. See chapter 7			
COOLANT TANK			
1. Drain old coolant, clean reservoir, refill with new coolant.			
SAFETY INTERLOCKS			
Emergency Stop - Check operation of all E-Stop buttons. Immediately replace a malfunctioning button.			
ATC Door - Verify operation of Safety Interlock switch. Immediately replace a malfunctioning switch.			
Rolling S/G Guard - Verify operation of Safety Interlock switch. Immediately replace a malfunctioning switch.			
OT2 Hard Overtravel - Verify operation of all overtravel limit switches. Check operation at both ends of travel in all axes. Immediately replace a malfunctioning switch.			

3.5 Leveling the Machine

When the equipment is first installed, the level and alignments are set. There are many variables which can affect the level and alignment (i.e. foundation or surrounding equipment and activity). It is a good practice to check the level and alignment of new equipment every three months until a proper assessment of the machine environment can be predicted. This will typically take the first year and **remember, the majority of movement will occur in the first three months**. (This check should not be included in the running record.)

Qualify the Precision Level(s)

Leveling the machine can be performed with one or two levels. Using two levels simplified the process, by allowing both planes (X and Y) to be viewed simultaneously. Before leveling the machining center verify your precision level(s) as follows:

1. Place a precision level on a clean flat surface. This surface need only be level enough to give a bubble reading that is not "bottomed" in the bezel.
2. Note the reading.
3. Rotate the level 180 degrees and check the reading. If reading is:
   A. Same as the first (bubble is in the same place, same side of bezel), the level is accurate and repeatable. Go to step 5.
   B. Different, the level needs to be calibrated. Got to step 4.
4. Calibrate the level. All precision levels are provided with adjustment screws for calibration. Adjust the level and repeat steps 1 through 3 until the level is calibrated.
5. Level the machine.

Level the Machine

The leveling procedure describe using two levels. If only one level is used, set the level in the X axis plane, note the reading and make a level adjustment; move to the Y axis plane, note the reading and make a level adjustment. Repeat the X and Y readings and level adjustments until the machine is level.

Level the machine as follows:

1. Place a precision level on the table, parallel with the X axis plane and a second level parallel with the Y axis plane, as shown in Figure 3-5.
2. Loosen the set screws on the two leveling bolts, see DETAIL A in Figure 3-6.
3. Adjust the leveling bolts to obtain level and a minimum clearance of 30mm (1.2 inches) between the bed bottom and the floor.
4. Tighten the set screw on each leveling bolt.
5. Remove the precision levels from the table.

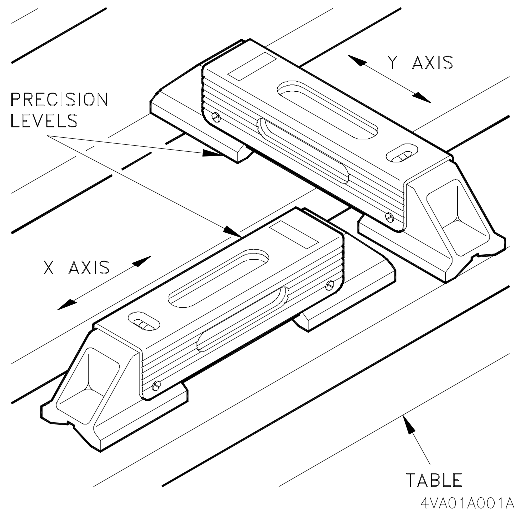


FIGURE 3-5 PRECISION LEVELS ON TABLE

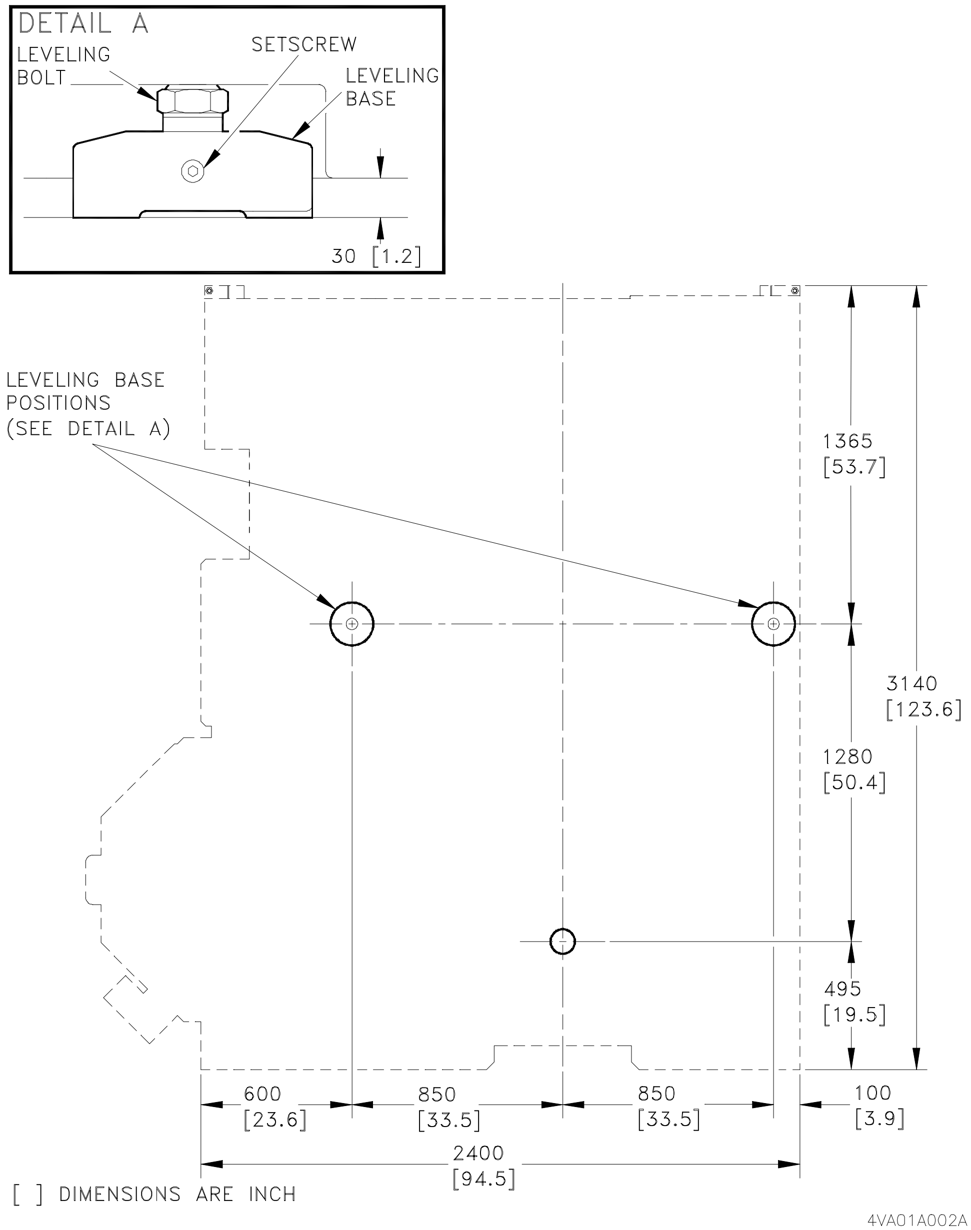


FIGURE 3-6 LEVELING BASE POSITIONS AND BED TO FLOOR CLEARANCE

NOTES:

SKETCHES:

Chapter 4 Machine Tool System Overview

Description of Basic Components, Communication Interface, and the PMC Address

Makino V55 High-speed Vertical Machining Center

Chapter 4
Machine Tool System Overview

Contents

4.1 Overview

Effective troubleshooting of any system or component must begin with a basic understanding of the operation of the system or component. An explanation of the Makino V55 machine tool system, its basic components, and operating principles follows.

An overview of the machine tool proper, its main components, and the machine tool system. The machine tool system consists of the MT (Machine Tool), the CNC (Computerized Numerical Controller), and the PMC (Programmable Machine Controller).

A description of the MT system's communication interface is also presented. Knowledge of the MT communication interface system will prove helpful in understanding and using the:

- CNC and PMC diagnostics
- CNC and Machine alarms
- PMC address

A working knowledge of the PMC address, CNC and Machine alarms, and diagnostics is essential for effective troubleshooting.

4.2 Description of Main Machine Components

The V55 provides efficient, highly accurate machining, and standard Makino control features.

Unique design features include:

- Unitized design with rigid column and bed that permits 3-point leveling, reducing special foundation requirements.
- Combined high-speed capabilities (high-speed spindle, feedrates, and automatic tool changing).
- Spindle technology and enhanced spindle control, with integral spindle motor, large spindle bearings, and spindle cooling and lubrication system.
- Effective chip disposal.
- Makino's GI (Geometric Intelligence) motion control technology.
- Heat source isolation:
    - Cooling oil is circulated through the center of axes ball screws and the face of the column. Oil temperature is maintained to the bed temperature.
    - Heat producing components (oil controller and hydraulic unit) are located at the rear with triple shield plates and fan circulated air between these heat sources and the machine.
    - Machine surfaces have covers to prevent contact with hot chips and coolant.

4.2.1 Core Components

Figure 4-1 shows the machine's core elements (bed, table, column, ram, spindle head, and saddle), without covers or guarding.

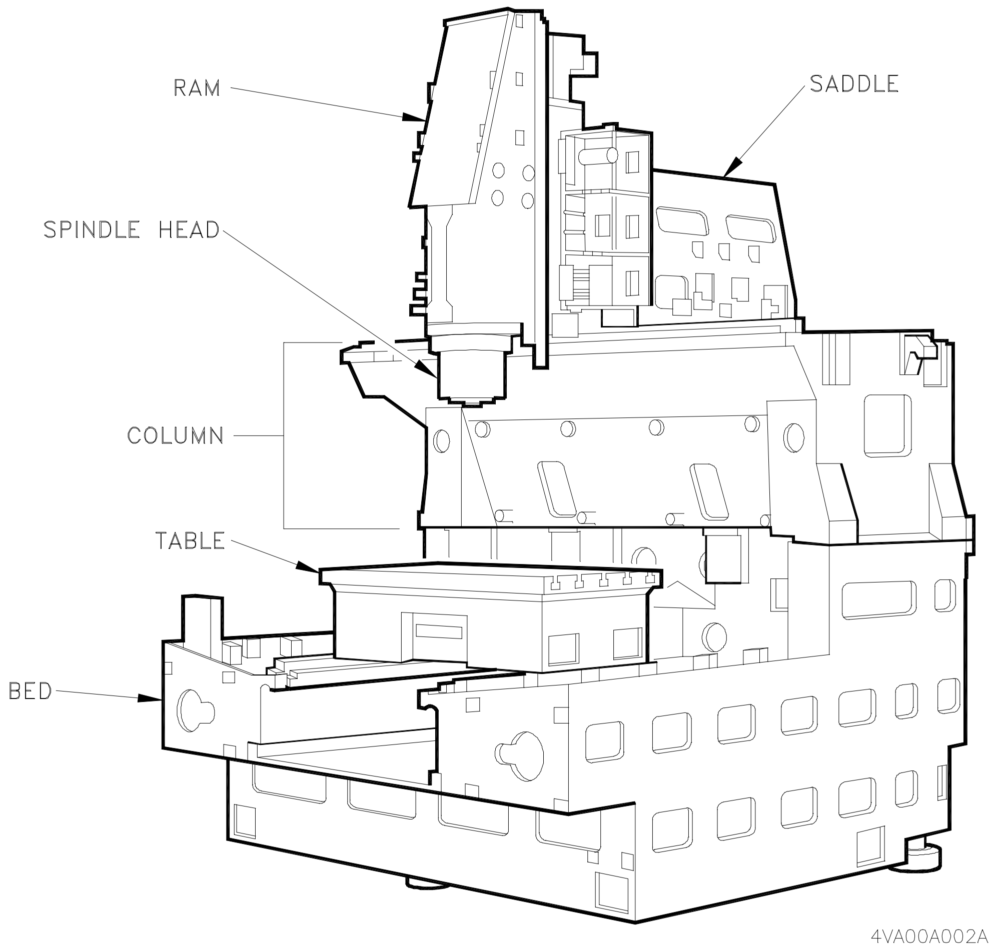


FIGURE 4-1 MACHINE CORE ELEMENTS

4.2.2 Major Machine Components

Major machine components are shown in Figure 4-2 and described below:

1. Table – forms the Y axis, traveling in a lengthwise direction (to and from column) with T-slots for mounting of fixtures and workpieces,
2. Ram and Spindle Head – the ram forms the Z axis, traveling vertically (down to and up from the table) and is mounted to the front of the saddle by LM (Linear Motion) guides. The spindle head is mounted to the ram. The V55 spindle has an integral motor with a standard speed range of 15 to 14,000 rpm, programmable in 1 rpm increments.
3. ATC (Automatic Tool Changer) operation panel – is used to manually index the magazine when loading and unloading tools.
4. ATC Unit – an armless-type magazine, the standard ATC holds 25 tools (optional 40 and 80 tool magazine are available).
5. Saddle – travels (with ram) in a transverse direction (right to left) forming the X axis and is mounted on top of the column with LM guides.
6. Bed and Column – form the solid foundation of the machine tool. Their design and rigidity ensures the squareness and straightness of axes movement.
7. Oil Controller – conditions oil temperature to control thermal distortion. A bed mounted thermocouple monitors machine temperature and maintains oil temperature within ± 1° C of the bed. Oil circulates through the spindle head (spindle core, bearing, and jacket), ball screws, and machining area.
8. Coolant Tank with Chip Bucket – the coolant tank is a 550 liter coolant reservoir, located under the MTC. Coolant is pumped from the tank to the coolant delivery system(s). The chip bucket collects the chips, for disposal.
9. MTC (Machine Tool Cabinet) – houses the machine's electrical components, CNC, spindle and axes servo drives, and other related components.
10. Electrical Transformer – is a 65 kVa transformer. The transformer is cabinet mounted in most countries. In the U.S. it is external and must be located within a 6-foot radius of the MTC.
11. Main Power switch – controls power (On and Off) to the machine tool. It is mounted on face of the MTC.
12. Hydraulic and Air Unit – this cabinet houses the hydraulic and air control equipment.

13. Main operation panel – provides the controls and screen display used to operate the machine. The panel swings 90°, allowing flexibility of operation.
14. Splash Guard – fully encloses the work zone containing chips and coolant and protecting the operator. The splash guard door slides to provide a 920mm (36") opening with top access, for loading and unloading.

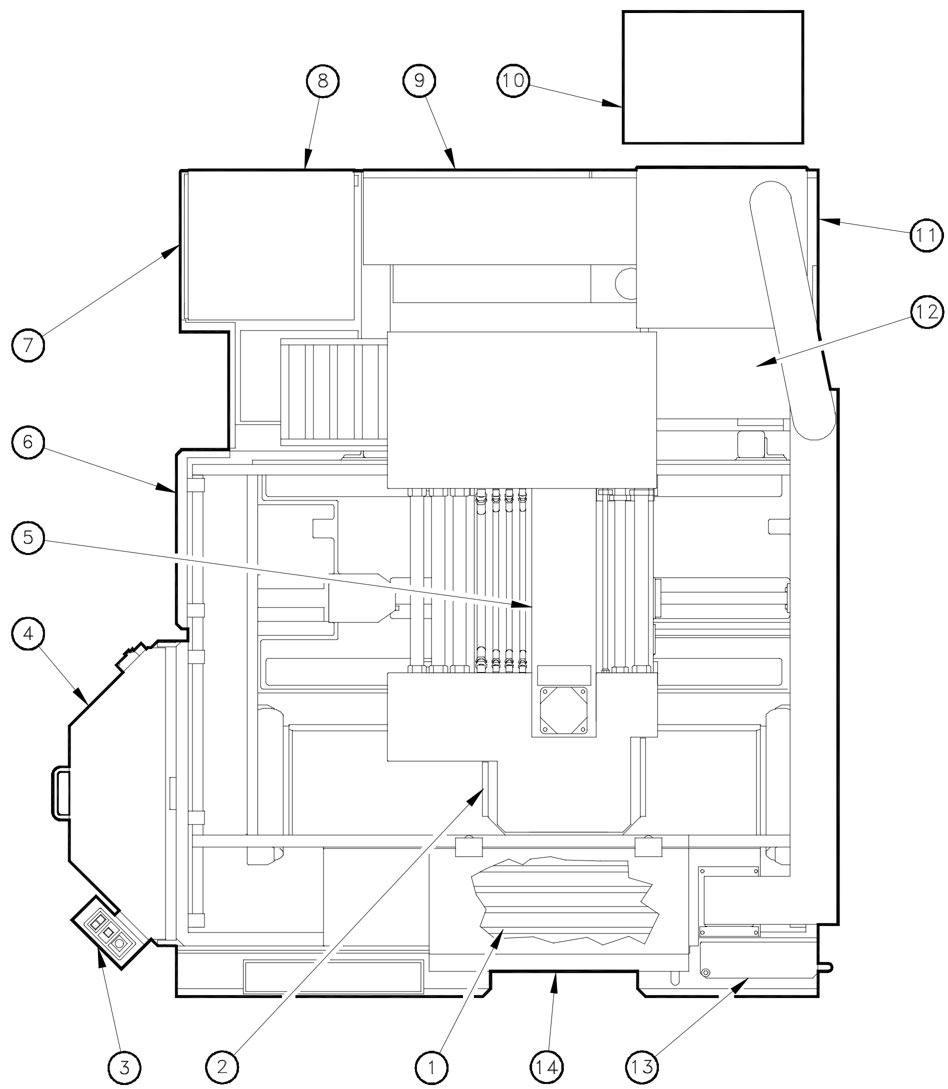


FIGURE 4-2 MAIN MACHINE COMPONENTS LOCATIONS (PLAN VIEW)

4.3 Makino Professional 3 Control

Makino uses the PRO 3 (Professional 3) series control to operate the V55. The PRO 3 consists of:

- Fanuc 16M hardware for both the CNC and the PMC
- Fanuc 16M operating software for control of the CNC
- Makino PMC operating software for control of the MT

Makino PMC software changes the 16M into a PRO 3 control. Makino PMC software is called the Custom or PMC software and controls all machine side operating features and options.

The PRO 3 provides two distinct areas of operation; The CNC side and the Custom side.

Some functions on the CNC and Custom side duplicate basic functionality. The Custom side was developed to provide enhanced functionality and features not available on the standard 16M.

4.3.1 Makino PRO 3 Features

The PRO 3 makes the PMC your window to the MT system:

- Enhances the standard Fanuc 16M package with Makino Custom software
- Provides more displays and information, enhanced functions, and easy operation

Figure 4-3 shows some of the PRO3 additional features. Custom side features and capabilities include:

- PRIMARY OPERATION screen, for “at a glance” machine status
- TOOL DETAIL screen, with expanded tool data display and functions
- TOOL MONITOR screen, for monitoring Makino’s Spindle Load, Tool Life, and Adaptive Control features
- DIAGNOSTIC screen, with split screen I/O signal display

We recommend, our customers use the Custom side features to realize the full potential of their machine tool investment.

Effective use of Custom features requires minor changes in programming or operation, discussed in the Operation Guide.

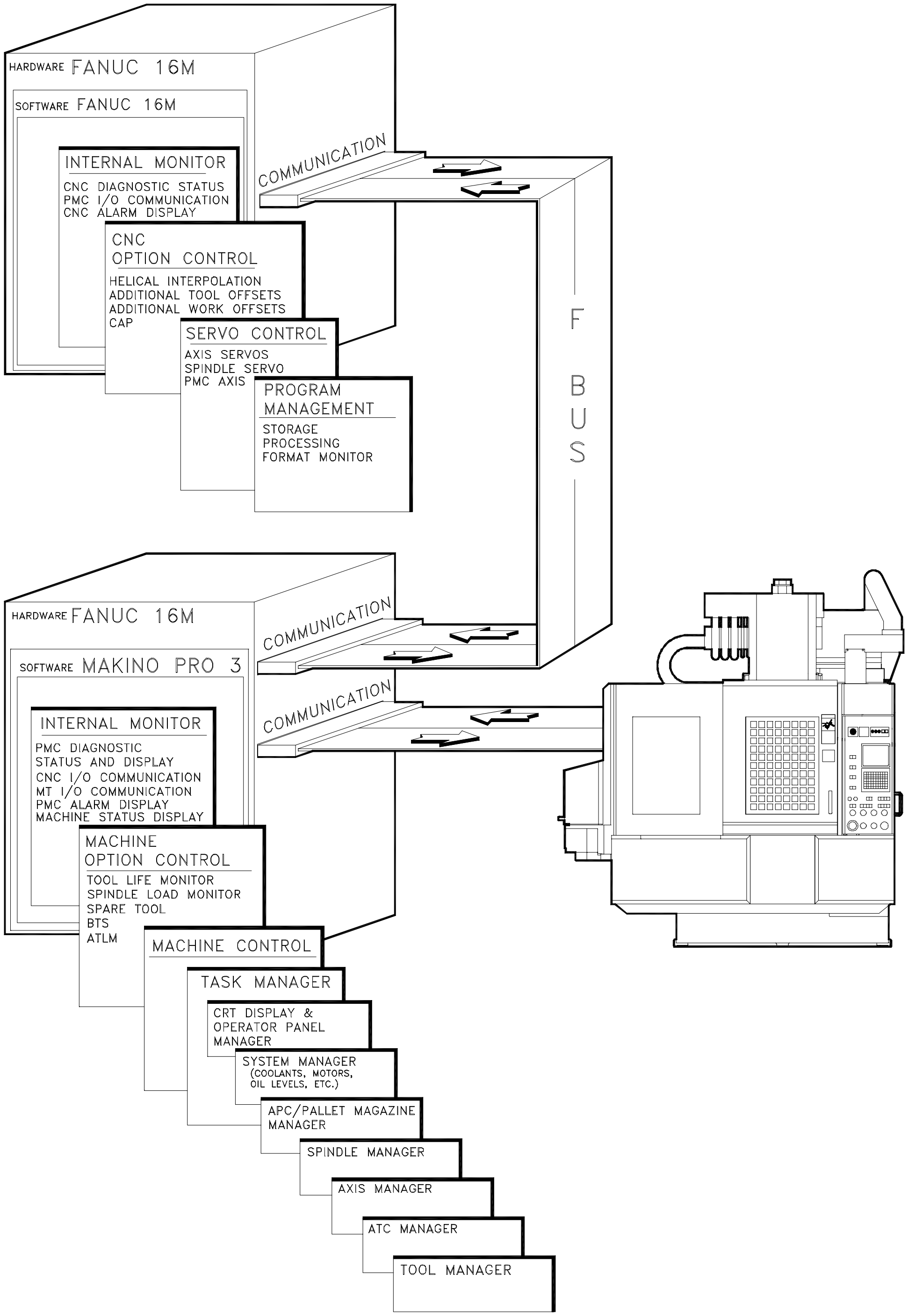


FIGURE 4-3 MAKINO PROFESSIONAL 3 CONTROL WITH MPC5

4.3.2 Basic Components

The V55 machine tool system has three basic components, shown in Figure 4-4 and described below.

1. The CNC (Computerized Numerical Controller) – The CNC is the initial controller/processor in the machine tool system as it receives and performs the initial processing of the program data.

   The CNC is used for:

   - Program storage and execution
   - CNC side operations and option control
   - Axis and Spindle Servo control
   - Internal I/O and Alarm display
   - Communication with the PMC

   The CNC is referred to as the Control or CNC side of the system and consists of Fanuc 16M series hardware and software.

2. The PMC (Programmable Machine Controller) – The PMC is the intermediate controller/processor in the machine tool system. The PMC receives information from and coordinates communication between both the CNC and MT.

   The PMC is used for:

   - Communication with the CNC
   - Communication with the MT
   - Internal I/O and alarm display
   - Machine side operations
   - Option control

   The PMC is referred to as the Custom or Machine side of the machine tool system and consists of Fanuc 16M hardware with Makino PMC software installed.

3. The MT (Machine Tool) – The MT is the machine itself. The machine proper consists of the axes (X, Y, and Z), the spindle, ATC (Automatic Tool Changer), tool magazine and related components, and any options such as AMS (Automatic Measuring System), ATLM (Automatic Tool Length Measuring), APC (Automatic Pallet Changer), etc.

   The MT resides at the end of the communication chain and is controlled by the PMC, with the exception of the axes and spindle servos which are controlled by the CNC.

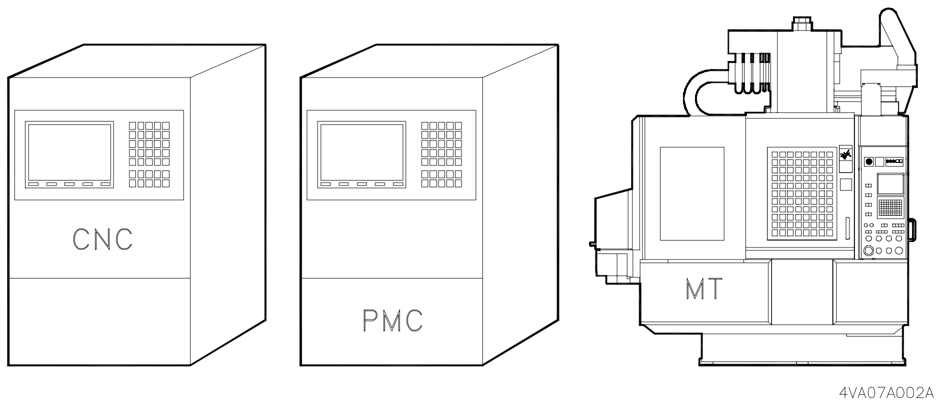


FIGURE 4-4 SYSTEM COMPONENTS

NOTES:

SKETCHES:

4.4 Machine Tool System Interface

The machine tool system includes the basic machine tool system components; the MT and PRO 3 control (which includes the CNC and PMC).

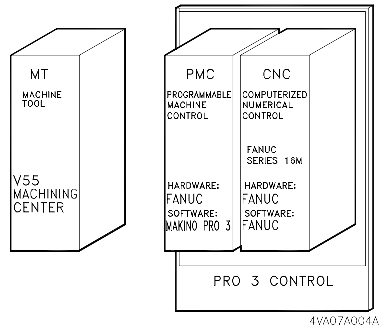


FIGURE 4-5 INTERFACE COMPONENTS

The system interface provides a method of controlling and communicating data and information among the separate components. It is this communication/control "interface" which transforms the separate components into a machine tool system, as shown in Figure 4-6.

The system interface is set up like most computer systems. Communication signals (inputs and outputs) are viewed by the system interface to determine the current status of various system components.

Signals are carried on the F-BUS (Fanuc Bus), which is a common bus, shared by the CNC and PMC (Figure 4-7 (pg. 4-12)).

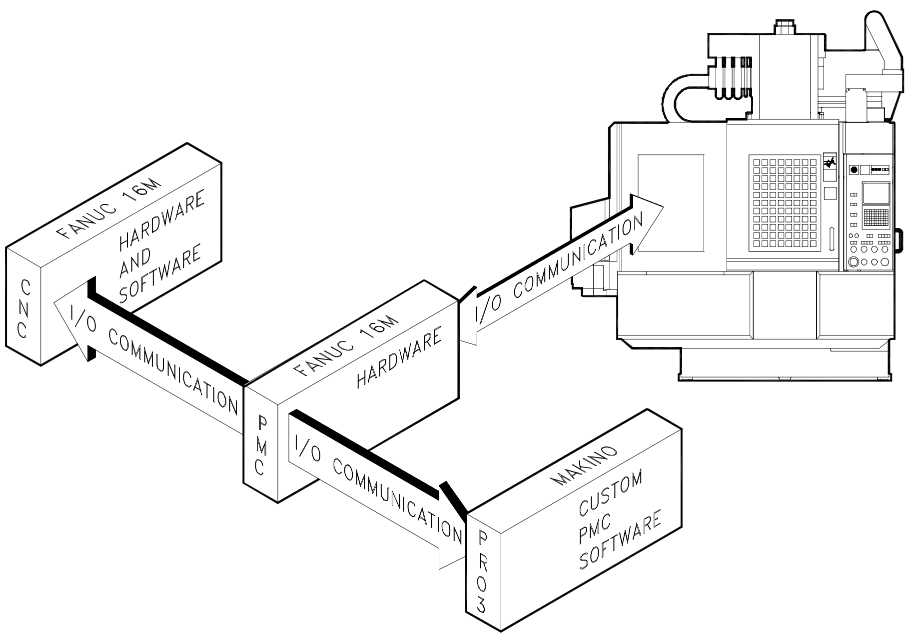


FIGURE 4-6 MACHINE TOOL SYSTEM INTERFACE

4.4.1 CNC to PMC Communication

The basic components of the CNC to PMC communication interface are shown in Figure 4-7.

- The CNC controls axis positioning, internal I/O, program storage/execution, and communication with the PMC.

When program data is input (via MDI, Memory, or Tape) the CNC processes the data on several levels and assigns the data as either:

CNC (Control side) data – like axis positioning and G code processing.

PMC (Machine side) data – like M, S, or T code processing.

CNC data is processed by the CNC's software and internal communication system via the F-BUS. PMC data is sent, via the F-BUS, to the PMC for processing.

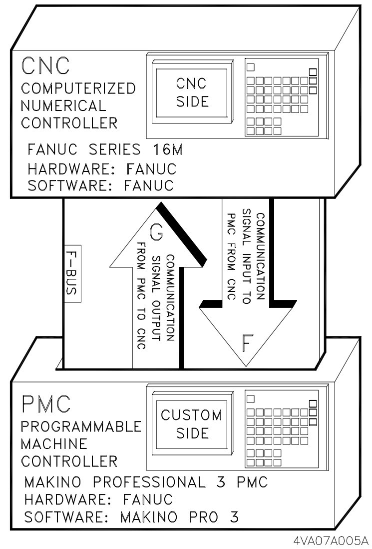


FIGURE 4-7 CNC – PMC COMMUNICATIONS

- Communication signals between and within the CNC and PMC are called DI (data input) and DO (data output) or I/O (Input/Output) signals.

4.4.2 PMC to MT Communication

The basic components of the PMC to MT communication interface include the; PMC, I/O Link, I/O Rack, and MT, as shown in Figure 4-8.

When data is received from the CNC the PMC:

1. Determines the software area the data pertains to.
2. Sends the data to the proper area of the machine control software.
3. Processes the data. Data processing is determined, affected, and monitored by the inputs being received from the MT or related components.
4. Sends an output signal (FIN (finished) signal) allowing the CNC to resume automatic operation.

Machine functions are controlled by DO signals from the PMC to the MT and Machine status is monitored via DI signals from the MT to the PMC.

Since the PMC to MT communication signals require very low voltages (usually 5VDC) the F-BUS terminates at the PMC and an I/O rack forms the communication link from the PMC to MT. The I/O rack contains a number of I/O Modules (based on machine configuration). It is the I/O rack's job to receive low voltage signals from the PMC via the I/O link and convert them to the higher voltage (usually 24VDC) needed for operating machine mounted devices, like solenoid valves and limit switches.

- The I/O rack is considered a Machine side component and is located in the MTC (Machine Tool Cabinet).

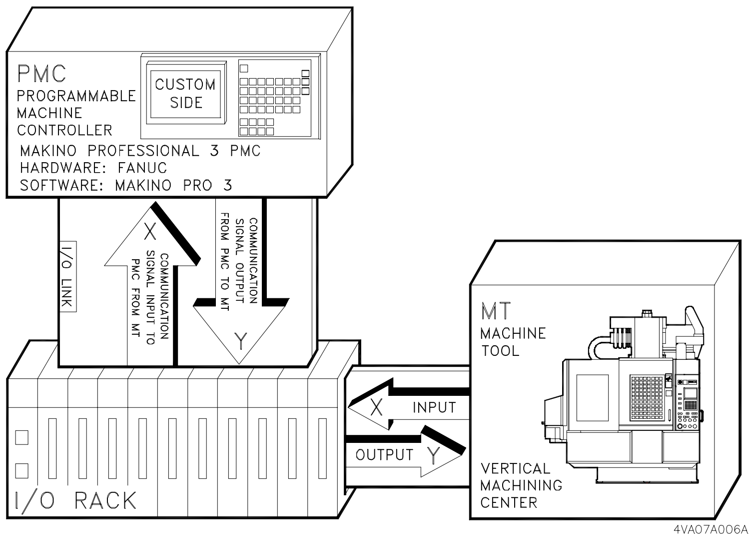


FIGURE 4-8 PMC – MT COMMUNICATION

4.5 The PMC Address

As the intermediate processor in the system interface, the PMC sends and receives signals to and from the CNC and MT. System communications is designed using the PMC as the center of communication and labels these signals with a PMC address to denote the direction of signal flow, within the system (Figure 4-9).

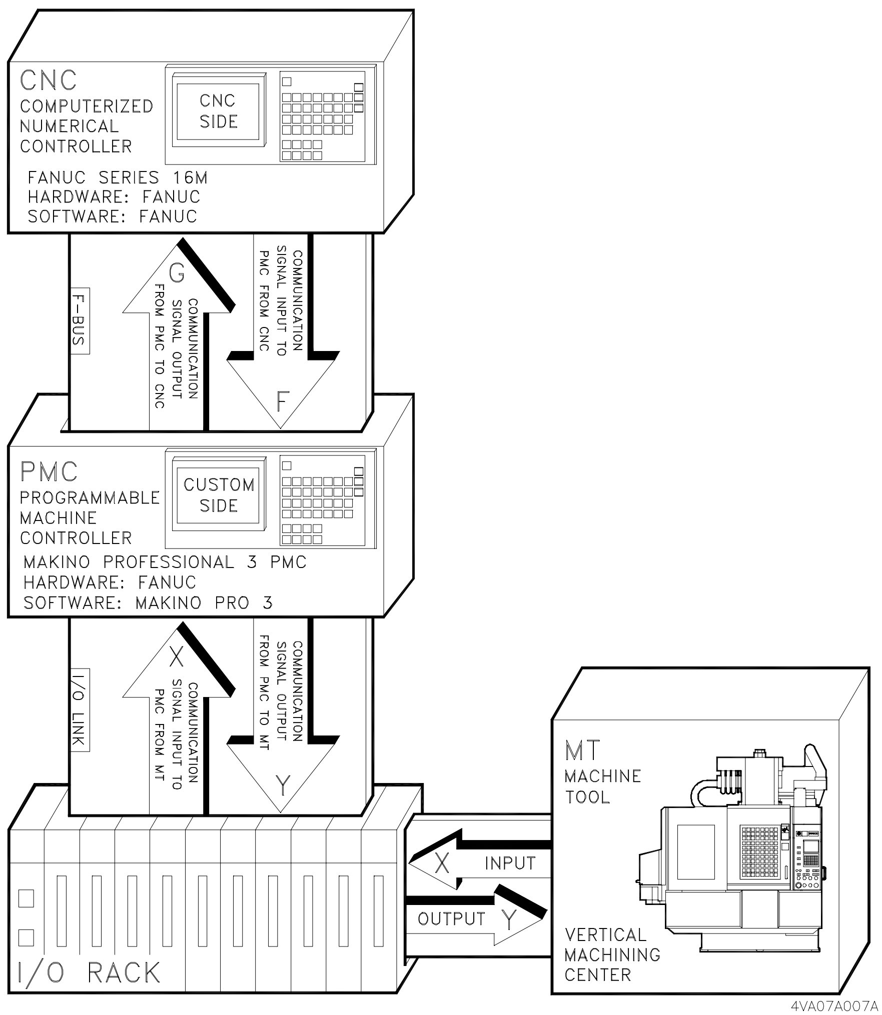


FIGURE 4-9 PMC ADDRESS FLOW

The PMC address consists of: (Figure 4-10).

1. Prefix – determines direction of communication flow.
2. Address Number – isolates communication to a specific address location.
3. Data Bit Location – provides the location of a specific signal.

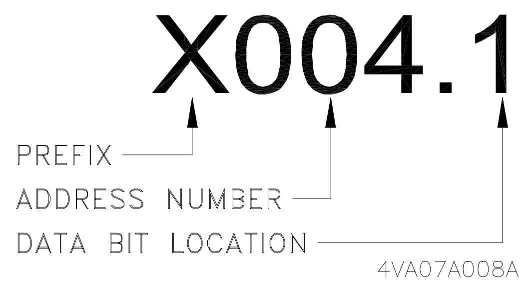


FIGURE 4-10 PMC ADDRESS COMPONENTS

Prefix

Signals between the PMC and MT have address prefixes of X or Y. An X address denotes a DI to the PMC from the MT and a Y address denotes a DO from the PMC to the MT.

- To simplify troubleshooting the Machine side (PMC to MT), X and Y PMC addresses are presented in the schematics, showing the direction of signal flow.
- A list of the PMC to MT diagnostic (X and Y) is provided in appendix B.

Signals between the CNC and PMC have address prefixes of F and G. An F address denotes a DI to the PMC from the CNC and a G address denotes a DO to the CNC from the PMC

- These signals are considered internal to the Makino PRO 3 system and are not typically shown in the schematics.
- A list of the CNC to PMC diagnostic signals (F and G) is provided in the CNC Maintenance Manual provided with the machine.

Address Number

By design, many different communication signals are integrated into the system. The PMC has a set of registers assigned to system communication. These registers are divided into groups by PMC prefix (X, Y, F, or G) for communication flow. Each register is assigned a PMC address number, providing a location within the system, so specific signals can be viewed and used by the system software and you.

- Each PMC address number consists of eight data bits. A specific communication signal can be assigned to each data bit along the address.

Data Bit Location and Display

There are eight data bits per PMC address. The number to the right of the decimal point represents a signal's data bit location.

- Data bits are numbered zero (0) through seven (7) and read from right to left, as shown in Figure 4-11.
- Data bits display the current "state" or status of the assigned signal. Typically a 1 indicates that a signal is High or ON, and a 0 indicates that signal is Low or OFF (some signals are held High (normally closed) so 1 = Off and 0 = On).

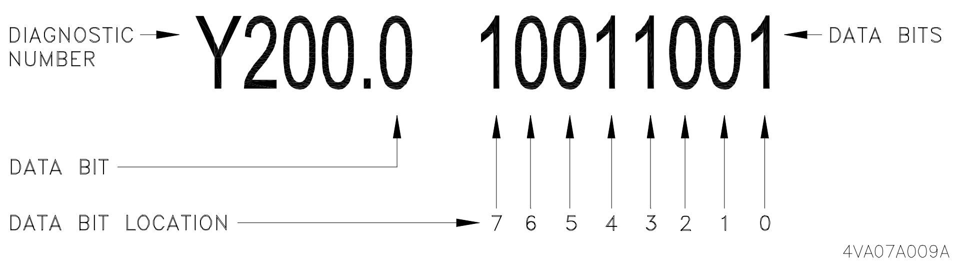


FIGURE 4-11 DATA BIT LOCATION

4.6 Troubleshooting and the PMC Address

The PMC address is a powerful tool on troubleshooting and diagnosing system faults. The PMC address is used in the:

- Schematics (Machine Electrical Drawings) to indicate signal names.
- PMC Diagnostic I/O function on both the CNC and Custom side displays.
- In the mechanical chapters, for each machine unit.

Each of these items are discussed in more detail in chapter 5.

NOTES:

SKETCHES:

Chapter 5 Troubleshooting

MT System Troubleshooting Guidelines and Techniques

Makino V55 High-speed Vertical Machining Center

Chapter 5
Troubleshooting

Contents

5.1 Overview

This chapter provides information on troubleshooting the MT system and more detail on using this guide.

The most difficult part of troubleshooting is determining “Where to begin?” It is always best to begin with an understanding of the system and its operating principles. It is, however, imperative to begin with the basics described in.

Detail on the use and operation of the troubleshooting tools available on the Custom and CNC sides of the MT system are provided to ensure effective diagnosis of system faults.

An overview of the schematics (machine electrical drawings) describing layout and road mapping is also presented.

Use this chapter in conjunction with other chapters in this guide, the schematics, and the CNC Maintenance Manual.

- In the event your preliminary checks prove unsuccessful, call your Makino service group.

5.2 Troubleshooting Guidelines

When diagnosing a problem on any piece of equipment, regardless of the fault, follow these basic guidelines:

Confirm The Fault

This is simply making certain you know what the symptoms are.

Be sure you understand the situation surrounding the occurrence.

- This is particularly important when investigating a fault for someone else who may not have described it accurately. Do not assume, guess, or suppose.

Don't Overlook The Obvious

For example, if a car won't start, is there gas in the tank? (Don't take anyone's word on this and don't trust the fuel gauge either).

Cure The Disease, Not The Symptom

Changing blown fuses with “good” ones will get you up and running, but if fuses continue to fail, the “cause” will need to be determined and corrected.

Take Nothing For Granted

Don't forget that “new” components may be defective, and don't eliminate recently changed, repaired, or adjusted components from the troubleshooting process.

5.2.1 Troubleshooting and Diagnosis

Preventive Maintenance needs to be mentioned, as those companies performing maintenance at the recommended frequencies should use this chapter less often.

Modern component reliability is such that, when items subject to wear or deterioration are inspected or renewed at the specified intervals, sudden failure becomes reasonably rare.

Those components that can fail without warning (fuses, switches, filters etc.) are often small and easily kept on hand.

Major mechanical faults are generally preceded by characteristic symptoms over hours, weeks, or longer.

Electrical faults can be more puzzling than mechanical failures, but are no less susceptible to logical analysis, if the basic principles are understood.

The first step in any fault finding (troubleshooting) is deciding where to begin the investigation.

- Makino equipment is set up with two-level alarm and diagnostic displays, which provide key starting places for pursuing faults.
- In troubleshooting, a calm and logical approach will prove to be of the greatest benefit. Think it through. Avoid the haphazard adjustment syndrome.
- Always take into account any telltale warning signs or abnormalities which may have been noticed prior to the fault – power loss, high or low gauge reading, sounds, smells, etc.
- Question the operator about what the machine was doing at the time of the failure.
- Remember, failure of components such as fuses or thermal relays may only be indicators of some underlying fault.
- It is a good idea to keep a log on machine problems and their remedies, as well as a record of maintenance and adjustments for future reference and time saving.

5.3 Basic Troubleshooting

Troubleshooting is the logical elimination of all necessary steps in a process or the potential variables within a step until the "Fault" is uncovered.

1. When a fault arises, gather as much information as possible about the events leading up to the fault. This often eliminates many steps in the troubleshooting process.
2. Determine where the fault resides. "Is this a Machine or CNC fault?"
3. Begin with the basic question of whether power exists. If power does not exist, ask the following questions:
   - Is there power at the source? – Check power at the source.
   - Is there power to the machine? –Check power at the main disconnect on the machine, refer to the schematics.
   - Is there power to the control? – Check the CNC Maintenance Manual for details, see section 5.4.2.
4. After confirming that power exists and the control and machine are "On," ask:
   - Is the machine READY? – See Figure 5-1.
   - Is the control READY? – See Figure 5-1.

Continuing in this manner should lead to the source of the Fault.

If in doubt, it is always safe to start at the beginning. The flow chart, in Figure 5-1, will prove helpful in beginning the troubleshooting process.

If the machine and control are both READY and an alarm is generated, finding the cause of the fault is greatly simplified:

1. Determine if the alarm is a CNC alarm or a Machine alarm.
2. Look up the proper alarm listing in appendix A and pursue the fault.

If no alarm is displayed use the other available troubleshooting tools discussed in section 5.4 and section 5.5.

Notes for Figure 5-1

1. Machine and CNC alarms are listed in appendix A of this Maintenance Guide.
2. Refer to the CNC Maintenance Manual for more detail on CNC alarms.

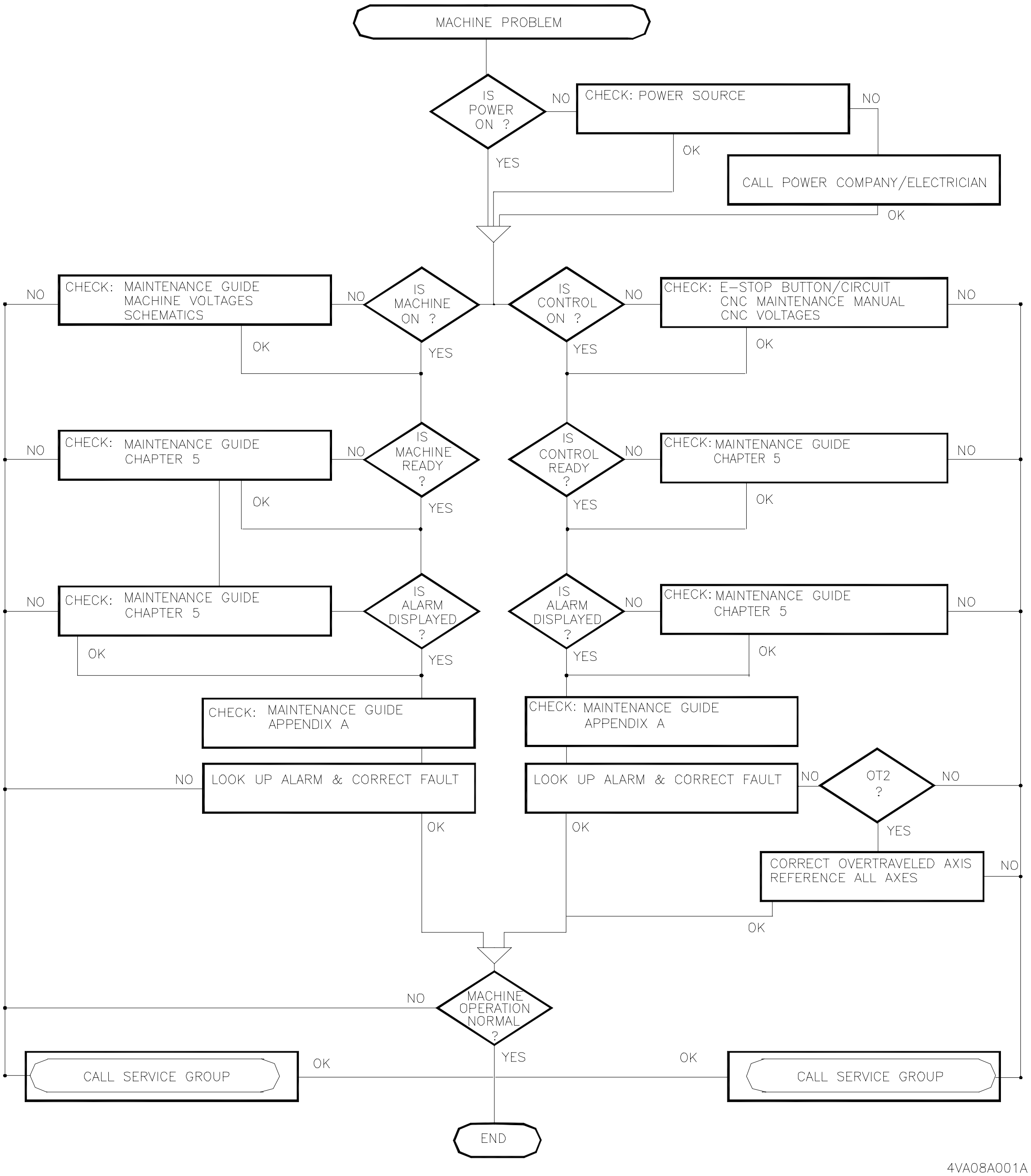


FIGURE 5-1 BASIC TROUBLESHOOTING FLOW CHART

NOTES:

SKETCHES:

5.4 CNC Troubleshooting

Details for troubleshooting CNC faults are presented below. The information includes:

- References to other chapters in this Maintenance Guide and the CNC Maintenance Manual.
- Information on the use of the CNC troubleshooting tools.
- Details on the CNC component self-diagnostic features.

For the most part, the CNC provides an alarm or other indicator leading to the cause of a system fault. Relatively few items, like power supplies or rare component failure, lead to NO alarm situations.

Typically Fanuc provides their components with board level diagnostic displays, power indicator LEDs and alarm status LEDs to assist in troubleshooting individual components or drives.

5.4.1 CNC Troubleshooting Tools

The troubleshooting tools provided for the CNC unit consist of:

- CNC Maintenance Manual
- CNC diagnostic status displays
- CNC alarm display function
- PMC diagnostic (I/O) display
- Component self-diagnostic displays

5.4.2 Troubleshooting and the CNC Maintenance Manual

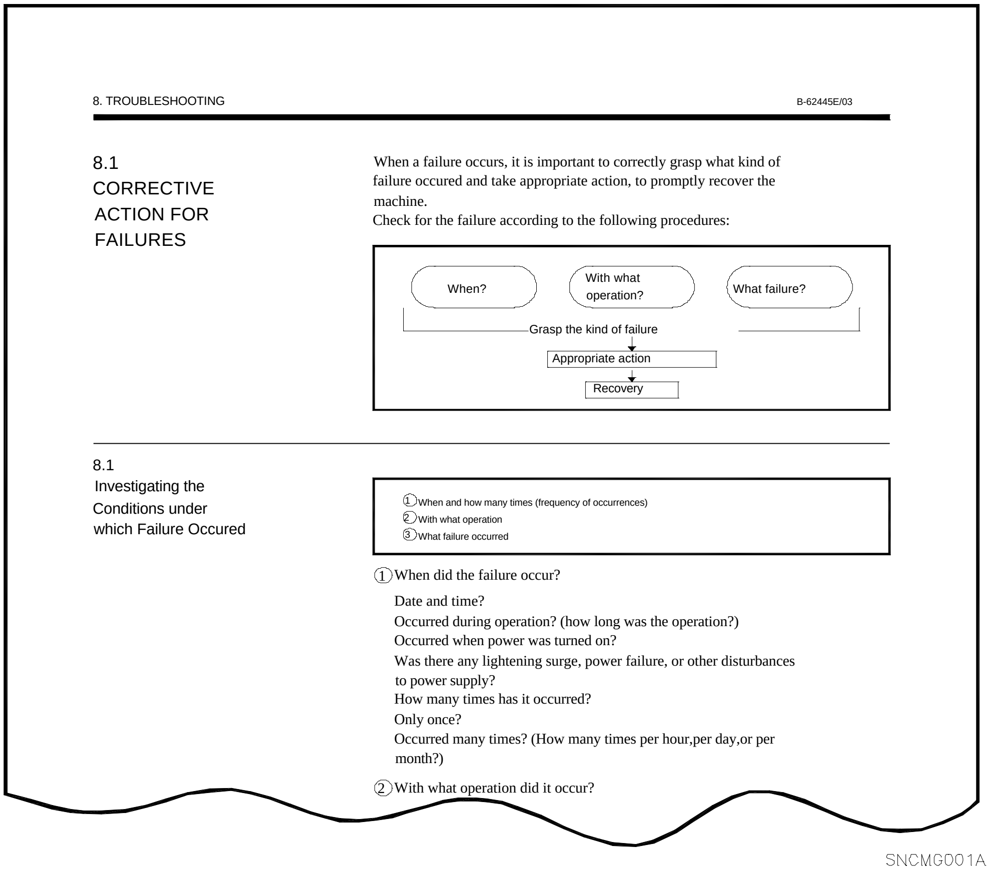
The CNC Maintenance Manual contains information required for investigating most CNC, axis servo, and spindle drive problems.

Look through the table of contents for headings related to your current situation. This will familiarize you with the CNC unit and the CNC Maintenance Manual. An index is also provided to assist in locating information by topic or name.

Figure 5-2 is a copy of the beginning to the TROUBLESHOOTING section of the CNC Maintenance Manual. This "TROUBLESHOOTING" is useful when pursuing any control problem, especially when no alarm is displayed.

Troubleshooting procedures are presented in several sections covering various areas, components, or symptoms, of the CNC, which might generate a failure. Each section, may reference other sections in order to check for possibly related faults/causes or provide more detail on components.

- Notice under Survey of the problem that Fanuc list items to note when a problem occurs. Each of these items is likely to affect the fault and must be considered as factors possibly related to the fault. These questions should become part of your initial research on any suspected CNC problem and you should be prepared to answer these questions if you call for service.


8. TROUBLESHOOTING B-62445E/03

8.1
CORRECTIVE
ACTION FOR
FAILURES

When a failure occurs, it is important to correctly grasp what kind of failure occured and take appropriate action, to promptly recover the machine.
Check for the failure according to the following procedures:

8.1
Investigating the
Conditions under
which Failure Occured

1 When and how many times (frequency of occurrences)
2 With what operation
3 What failure occurred

1 When did the failure occur?

Date and time?
Occurred during operation? (how long was the operation?)
Occurred when power was turned on?
Was there any lightening surge, power failure, or other disturbances to power supply?
How many times has it occurred?
Only once?
Occurred many times? (How many times per hour,per day,or per month?)

2 With what operation did it occur?

SNCMG001A

FIGURE 5-2 TROUBLESHOOTING (COPIED FROM FANUC CNC MAINTENANCE MANUAL)

Specifications Subject to Change

As design and specifications may change without notification, Figure 5-2 is presented only as an example,
We recommend referring to the CNC Maintenance Manual provided with the machine, for the latest information, detail, and changes.

5.4.3 Troubleshooter's Road map

This road map is provided to facilitate getting started troubleshooting the CNC.

The CNC side of the machine tool system consists of the CNC, axis servo drive, and the spindle servo drive. Each unit is Fanuc hardware and should be troubleshot accordingly.

5.4.3.1 No Alarm Displayed

If "normal operation" of the CNC side of the system is not possible and NO alarm is displayed, follow the suggestions provided below:

CRT Does Not Power On

1. See TROUBLESHOOTING in the CNC Maintenance Manual.
2. Check the CNC power supply board (PSU B1) PIL and ALM LED's. See section 5.4.7 (pg 5-26).
3. Check the CNC CPU main board STATUS LED's for alarm or abnormal status. See section 5.4.8.2 (pg 5-31).
4. Check axis servo drive unit PIL and ALM LED's and self-diagnostic displays for power or fault indications. See section 5.4.9 (pg 5-42).
5. Check the spindle drive unit PIL, ALM, and ERR LED's and self-diagnostic displays for power or fault indications. See section 5.4.10 (pg 5-45).

CRT is On, But No Alarm is Displayed

1. Check internal status of the CNC, using the CNC DIAGNOSTIC STATUS function, see section 5.4.5 (pg 5-15).
2. Check the ALARM HISTORY display, to confirm that an alarm was not cleared accidentally, see section 5.4.4.2 (pg 5-14).
3. Refer to the TROUBLESHOOTING section in the CNC Maintenance Manual.

5.4.3.2 CNC Alarm is Displayed

The ALARM MESSAGE screen is displayed automatically when a CNC alarm occurs.

Axis and spindle servos are controlled by the CNC. Some servo alarms are displayed on the CRT and others are displayed on the drive unit's self-diagnostic display.

If an alarm is displayed on the CRT, proceed as follows:

1. Determine the type of alarm (CNC or Machine).
2. CNC alarms - Look up the alarm, see appendix A
3. Machine alarms - Look up the alarm, read screen detail.
4. SERVO alarm -
   A. Using the CNC Diagnostic Status function, check the DIAGNOSTIC (SERVO ALARM AND SERVO STATUS) screens, see section 5.4.5 (pg 5-15).
   B. Check the servo drive components self-diagnostic display for fault indications.
5. SPINDLE alarm -
   A. Using the CNC DIAGNOSTIC STATUS FUNCTION, check the DIAGNOSTIC (SPINDLE STATUS) screen, see section 5.4.5 (pg 5-15).
   B. Check the spindle drive component self-diagnostic display for fault indications.
6. SYSTEM alarm - Call your local Fanuc service group.

Reference

For a listing of CNC alarms see appendix A or refer to CNC Maintenance or Operators Manual, provided with the machine

5.4.4 CNC Alarm Display

The CNC alarm function consists of the ALARM MESSAGE and ALARM HISTORY screens. CNC alarms are divided into types by number groups, as shown in Table 5-1. An overview of the CNC alarm function follows.

- A complete listing of the CNC alarms is provided in appendix A.

5.4.4.1 Alarm Message Screen Display

The ALARM MESSAGE screen (Figure 5-3) displays:

The screen name, current program (Oxxxx) number and block (Nxxxxx) number across the top of the screen.

The alarm number(s), and brief error message(s).

At the bottom of the screen; the mode (AUTO), condition (STOP), a flashing alarm (ALM), and control clock are displayed.

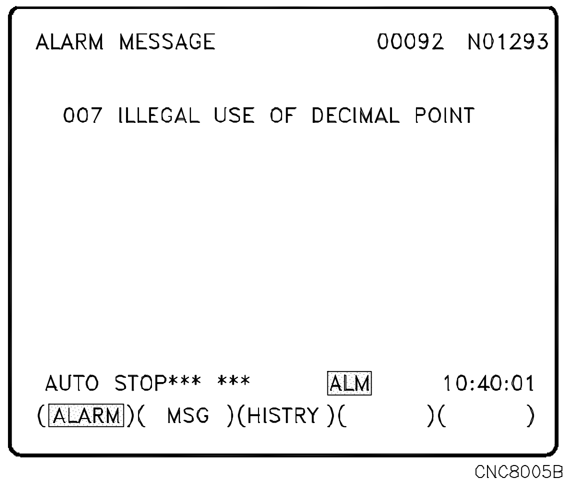


FIGURE 5-3 CNC ALARM MESSAGE SCREEN

Alarm Message Softkeys

The softkey menus listed below are for the ALARM MESSAGE screen and are highlighted when the respective screen is displayed.

[ALARM] – Displays the ALARM MESSAGE screen.

[MSG] – Displays the OPERATOR MESSAGE screen.

[HISTRY] – Displays the ALARM HISTORY screen (section 5.4.4.2).

TABLE 5-1 CNC ALARM TYPES

Alarm Range	Alarm Type	Alarm Type Description
000-299	P/S	Program/Set up alarms are caused by operator error or programming/set up errors (i.e. error in program format).
300-349	APC	Absolute Pulse Coder alarms, relate to storage/transfer of absolute position data.
350-399	SPC	Serial Pulse Coder alarms are position data communication faults.
400-499	SV	SerVo alarms are generated by faults in the axis servo systems on the machine. NOTES**:** 1. Axis servo control is performed by the CNC. 2. Servo Drive components have self-diagnostic displays, see section 5.4.9.
500-507	OT	Over Travel alarms occur when an axis exceeds its allowable range of movement.
700-730	OH	OverHeat alarms, check the control unit and spindle unit for excessive heat.
750-799	SP	SPindle alarms are generated by errors in serial communication and should be used in conjunction with the spindle drive unit self-diagnostic display, see section 5.4.10.
900-999	SYS	SYStem alarms are generated by errors in system hardware/software.

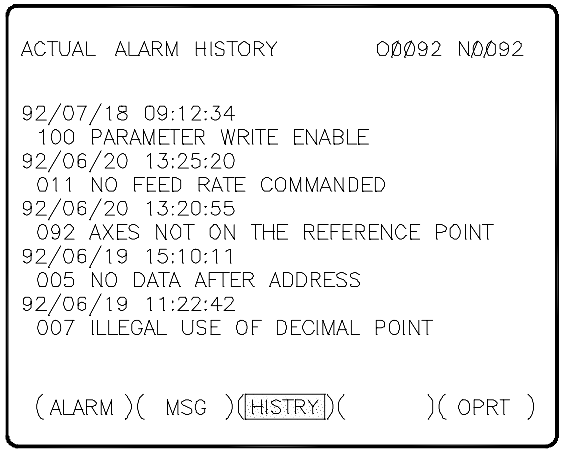
5.4.4.2 Alarm History

The ALARM HISTORY screen, Figure 5-4, provides a record of the last 25 CNC alarms generated.

Each record consists of; the date (year/month/date), the time (military time), the alarm number, and a brief error message.

The first alarm record on page 1 is the most recent alarm and the alarm at the bottom of page 5 is the 25th or oldest alarm.

Use the page [↑]/[↓] keys, to move between the pages of the ALARM HISTORY screen.



CNC8006B

FIGURE 5-4 CNC ALARM HISTORY SCREEN

Alarm History Softkeys

The softkey menus for the ALARM HISTORY function are;

[ALARM] – Displays the ALARM HISTORY screen.

[HISTRY] – Displays the ALARM HISTORY screen, [HISTRY] is highlighted when this screen is displayed.

[OPRT] – Provides menu for ALARM HISTORY screen operations.

[CLEAR] – Clears all alarms listed on the ALARM HISTORY screen.

More Detail

Refer to the CNC Operator's Manual for more information on the ALARM screen(s) and the CNC HELP feature and its relation to the alarm message function of the CNC.

5.4.5 CNC Diagnostic Status Function

This function displays signal status for internal CNC and CNC to PMC communication. Six diagnostic status displays categories are provided:

GENERAL (000 - 031)

SERVO ALARM (200 - 280)

SERVO STATUS (300 - 311)

SPINDLE STATUS (400 - 420)

RIGID TAPPING (450 - 457)

INDUCTOSYN (380 - 381)

- Each category contains several diagnostic status items. The range of numbers (in parenthesis) represents the assigned diagnostic numbers, within that category. These numbers can be searched to display the signal status of the listed diagnostic items.
- The following sections explain the CNC DIAGNOSTIC STATUS items within each category. Some items are assigned names, while others are shown in 8-bit signal format. Where applicable, tables are provided listing the diagnostic items.

5.4.5.1 CNC Diagnostic Status Display

To select the CNC diagnostic status function:

1. Press the [SYSTEM] function key.
2. Press the [DGNOS] softkey.
3. Select the proper diagnostic status screen
   A. Use the page [↑]/[↓] keys.
   B. Key-in the required number and press the [NO. SRH] softkey.

5.4.5.2 Diagnostic (General) Screen

The DIAGNOSTIC (GENERAL) screen (Figure 5-5) displays internal CNC status for:

COMMANDS APPARENTLY NOT EXECUTED (000 - 016)

STOP/IDLE STATUS (020 - 025)

TH ALARM STATUS (030 - 031)

and as detailed in Table 5-2.

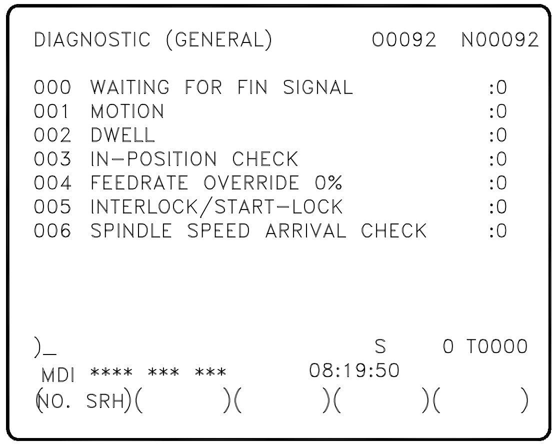


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FIGURE 5-5 DIAGNOSTIC (GENERAL)

TABLE 5-2 DETAILS OF CNC STATUS

No.	Display	Internal Status When 1 Is Displayed
Display of status in which command does not appear to be executed		
000	WAITING FOR FIN SIGNAL	M, S, T, or B function is being executed.
001	MOTION	Move command is being executed in automatic operation.
002	DWELL	Dwell is being executed.
003	IN-POSITION CHECK	In-position check is being performed.
004	FEED RATE OVERRIDE 0%	Override is set to 0%.
005	INTERLOCK/START-LOCK	One of the following conditions exist: 1. Interlock signal *IT (**G8.0**) is 0. 2. Axis interlock *IT1 (**G130.0**) to *IT2 (**G130.1**) is 0.
006	SPINDLE SPEED ARRIVAL CHK	Waiting for spindle speed arrival signal SAR (**G29.4**) to turn on.
010	PUNCHING	Data is being output via the reader/puncher interface.
011	READING	Data is being input via the reader/puncher interface.
012	WAITING FOR (UN)CLAMP	Waiting for index table.
013	JOG FEEDRATE OVERRIDE 0%	Jog feedrate is set to 0%.

TABLE 5-2 DETAILS OF CNC STATUS (CONTINUED)

014	WAITING FOR RESET, ESP, RRW OFF	One of the following conditions exists: 1. E-Stop *ESP (**X08.4 or G8.4**) is 0. 2. External reset ERS (**G8.7**) is 1. 3. The MDI panel reset button is on.
015	EXT. PROGRAM NO. SEARCH	External program number search is active.
016	BACKGROUND ACTIVE	Background editing mode is active.
Information indicating automatic operation stop/idle status		
020	CUT SPEED UP/DOWN	E-stop signal *ESP (**X08.4 or G8.4** =0), or servo alarm occurred.
021	RESET BUTTON ON	Set when the reset key is pressed.
022	RESET AND REWIND ON	Reset rewind signal RRW (**G8.6**) turned on.
023	EMERGENCY STOP ON	The emergency stop signal *ESP (**X08.4 or G8.4**) is 0.
024	RESET ON	One of the following conditions exists: 1. E-Stop signal *ESP (**X08.4 or G8.4**) is 0. 2. External reset signal ERS (**G8.7**) is 1. 3. The MDI panel reset button is on.
025	STOP MOTION OR DWELL	Pulse distribution halted when 1. Check: 1. External reset ERS (**G8.7**) is 1. 2. E-Stop *ESP (**X08.4 or G8.4**) is 0. 3. Automatic operation stop *SP (**G8.5**) is 0. 4. The MDI panel reset button is ON. 5. Switched to manual mode (JOG/HANDLE/ etc.). 6. Other alarm occurred or condition occurred for which no alarm exist.
TH ALARM STATUS		
030	CHARACTER NUMBER TH DATA	The position of the character causing the TH alarm is displayed, by No. of characters from the beginning of the alarmed block.
031	TH DATA	Read code of character which triggered the TH alarm.

5.4.5.3 Diagnostic (Servo Alarm) Screen

The DIAGNOSTIC (SERVO ALARM) screen (Figure 5-6) displays internal CNC status for various axes servo system alarm conditions.

Some servo alarms display a CNC alarm, on the CRT. Alarm conditions are diagnosed by viewing signal status on the CNC DIAGNOSTIC (SERVO ALARM) screens.

Servo alarm related diagnostic numbers range from 200 to 280.

Table 5-3 lists the diagnostic number-to-CNC alarm relationship.

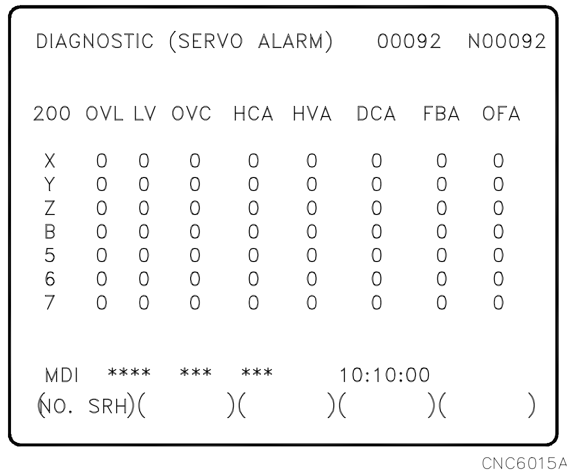

FIGURE 5-6 DIAGNOSTIC (SERVO ALARM) SCREEN

TABLE 5-3 ALARM TO DIAGNOSTIC CROSS-REFERENCE

CNC Alarm No.	Alarm Name	Diagnostic No.
350	SPC ALARM: n-TH AXIS PULSE CODER	200 and 204
351	SPC ALARM: n-TH AXIS COMMUNICATION	203
410	SERVO ALARM: n-TH AXIS - EXCESS ERROR	300
411	SERVO ALARM: n-TH AXIS - EXCESS ERROR	300
414	SERVO ALARM: n-TH AXIS - DETECTION RELATED ERROR	200 and 204
Refer to the CNC Maintenance Manual for detailed servo alarm descriptions, checks, and remedies not provided in this manual.		

5.4.5.4 Diagnostic (Servo Status) Screen

The DIAGNOSTIC (SERVO STATUS) screen (Figure 5-7) displays internal CNC status for the axes servo system.

Table 5-4 lists the items displayed in the DIAGNOSTIC (SERVO STATUS) screens.

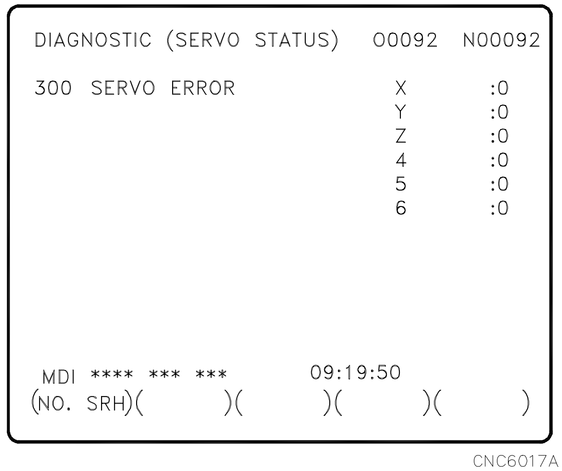

FIGURE 5-7 DIAGNOSTIC (SERVO STATUS) SCREEN

TABLE 5-4 DIAGNOSTIC (SERVO STATUS) ITEMS

Diagnostic No.	Status Item Name	Description
300	SERVO ERROR	Position error of an axis.
301	MACHINE POSITION	Distance of an axis from the reference point.
302	DIST. TO 1ST GRID	Distance from the end of the deceleration dog to the first grid point.
310	No Name - 8-bit format	Refer to the CNC Maintenance Manual.
311	No Name - 8-bit format	Refer to the CNC Maintenance Manual.

5.4.5.5 Diagnostic (Spindle Status) Screen

The DIAGNOSTIC (SPINDLE STATUS) screen (Figure 5-8) displays internal CNC status for spindle drive system.

Spindle drive system related diagnostic numbers range from 400 to 420.

Table 5-5 lists the items displayed on the DIAGNOSTIC (SPINDLE STATUS) screens.

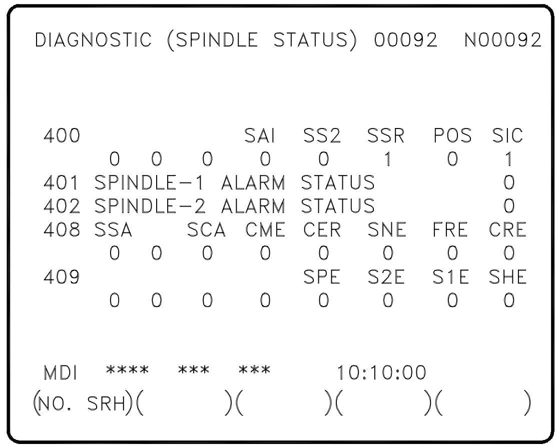

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FIGURE 5-8 DIAGNOSTIC (SPINDLE STATUS) SCREEN

TABLE 5-5 DIAGNOSTIC (SPINDLE STATUS) SCREEN ITEMS

Diagnostic No.	Status Item Name	Description
400	No Name - 8-bit format	Refer to the CNC Maintenance Manual
401	SPINDLE-1 ALARM	Serial spindle alarm state of 1st spindle.
402	SPINDLE-2 ALARM	Serial spindle alarm state of 2nd spindle.
408	No Name - 8-bit format	Refer to the CNC Maintenance Manual
409	No Name - 8-bit format	Refer to the CNC Maintenance Manual
410	SPINDLE-1 LOAD DATA	Load meter of 1st spindle (%)
411	SPINDLE-1 SPEED DATA	Speed meter of 1st spindle (%)
412	SPINDLE-2 LOAD DATA	Load meter of 2nd spindle (%)
413	SPINDLE-2 SPEED DATA	Speed meter of 2nd spindle (%)
414	SPINDLE-1 MOTION ERROR	Position error in 1st spindle synchronous control mode.
Refer to the CNC Maintenance Manual detailed spindle alarm descriptions, checks, and remedies not provided in this manual.		

TABLE 5-5 DIAGNOSTIC (SPINDLE STATUS) SCREEN ITEMS (CONTINUED)

415	SPINDLE-2 MOTION ERROR	Position error in 2nd spindle synchronous control mode.
416	SPINDLE SYNCHRO ERROR	Absolute value of synchronous error between 1st and 2nd spindle.
417	SPINDLE-1 POS. CODER	Feedback information of 1st spindle position coder.
418	SPINDLE-1 POS. ERROR	Position error of 1st spindle position loop mode.
419	SPINDLE-2 POS. CODER	Feedback information of 2nd spindle position coder.
420	SPINDLE-2 POS. ERROR	Position error of 2nd spindle position loop mode.
Refer to the CNC Maintenance Manual detailed spindle alarm descriptions, checks, and remedies not provided in this manual.		

5.4.5.6 Diagnostic (Rigid Tapping) Screen

The DIAGNOSTIC (RIGID TAPPING) screen (Figure 5-9) displays internal CNC status for rigid tapping.

Diagnostic numbers relative to rigid tapping range from 450 to 457.

Table 5-6 lists the items displayed on the DIAGNOSTIC (RIGID TAPPING) screens.

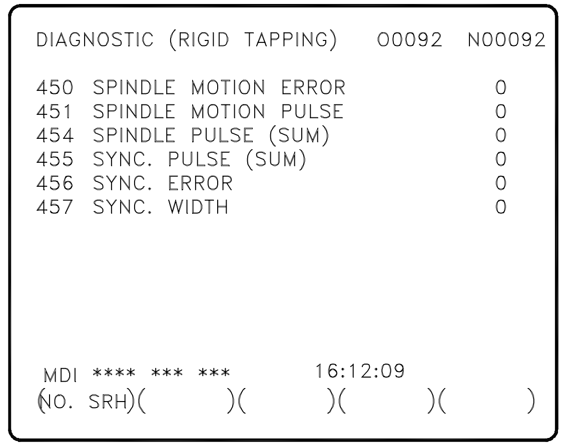

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FIGURE 5-9 DIAGNOSTIC (RIGID TAPPING) SCREEN

TABLE 5-6 DIAGNOSTIC (RIGID TAPPING) SCREEN ITEMS

Diagnostic No.	Status Item Name	Description
450	SPINDLE MOTION ERROR	Spindle position error during rigid tapping.
451	SPINDLE MOTION PULSE	Spindle distribution during rigid tapping.
454	SPINDLE PULSE (SUM)	Accumulated spindle distribution during rigid tapping.
455	SYNC. PULSE (SUM)	Instantaneous difference for the move command, calculated in terms of the spindle, during rigid tapping (signed, accumulated value).
456	SYNC. ERROR	Instantaneous difference for the travel command, calculated in terms of the spindle, during rigid tapping (signed value).
457	SYNC. WIDTH	Width of synchronization error during rigid tapping (maximum value).

5.4.5.7 Diagnostic (Inductosyn) Screen

The DIAGNOSTIC (INDUCTOSYN) screen (Figure 5-10) displays internal CNC status for axes with inductosyn feedback scales.

Inductosyn scale related Diagnostic numbers are 380 and 381.

Table 5-7 lists the items displayed on the DIAGNOSTIC (INDUCTOSYN) screen.

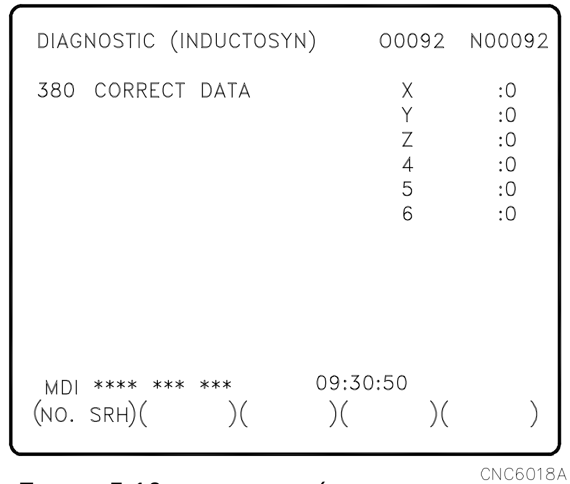


FIGURE 5-10 DIAGNOSTIC (INDUCTOSYN) SCREEN

TABLE 5-7 DIAGNOSTIC (INDUCTOSYN) SCREEN ITEMS

Diagnostic No.	Status Item Name	Description
380	CORRECT DATA	Distance between the absolute position of the motor and offset data.
381	OFFSET DATA	Offset data from the Inductosyn.

Option Detail

This screen and description applies only to inductosyn type feedback scales and does not apply to the V55.

5.4.6 CNC Diagnostic Display

PMC diagnostics are useful in troubleshooting the CNC, PMC, and the MT. Diagnostics allow you to see the current state (On/Off) of specific I/O signals, as viewed by the PMC.

The PMC is the origin of system communication and must see proper signal conditions to continue program processing. This makes the PMC diagnostics a key starting point in troubleshooting most MT system faults.

- See section 5.6 for more detail on this important troubleshooting tool.

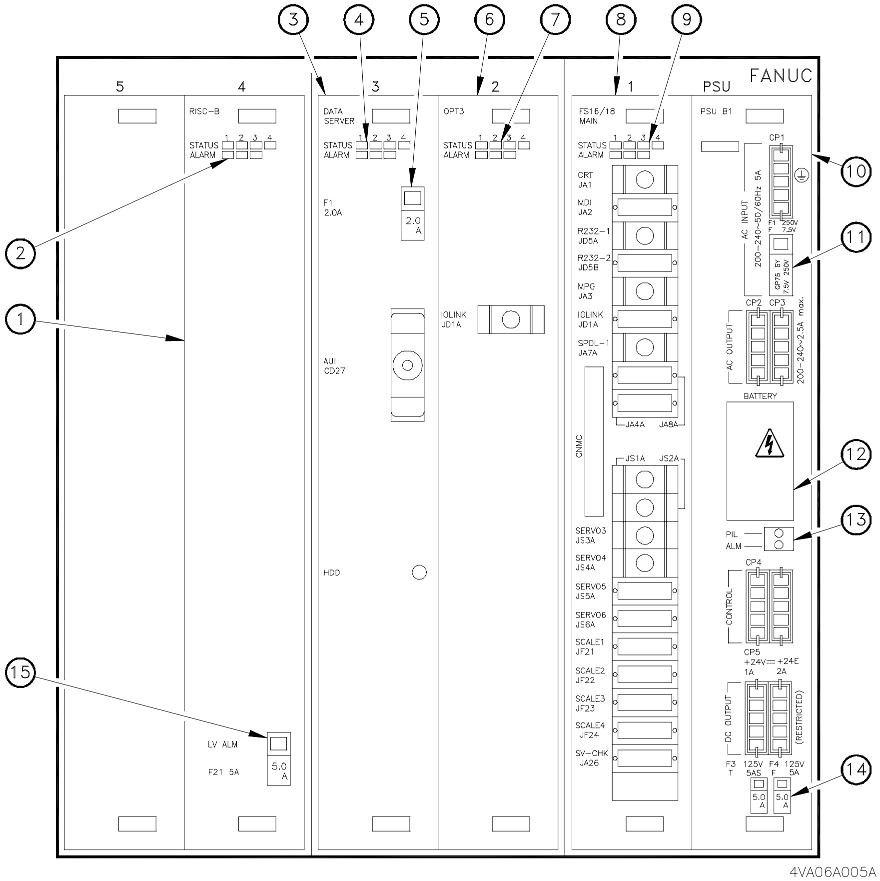
NOTES:

SKETCHES:

5.4.7 The CNC System

The CNC system consists of: the card cage, I/O rack, and CRT/MDI - Operation Panel. The card cage and its key components are shown in Figure 5-11 and the I/O rack is shown in Figure 5-12.

- For more information on the CRT/MDI - Operation Panel, refer to the CNC Maintenance Manual or the V55 Operation Guide.



Legend

[1]	RISC-B Board	[9]	Main Status/Alarm Display
[2]	RISC-B Status/Alarm Display	[10]	PSU-B1 Board
[3]	Data Server Board	[11]	Fuses
[4]	Data Server Status/Alarm Display	[12]	Backup Battery
[5]	Fuse	[13]	PIL and Alarm LEDs
[6]	OPT3 Board	[14]	Fuses
[7]	OPT3 Status/Alarm Display	[15]	Fuse
[8]	Main Board		

FIGURE 5-11 CNC COMPONENTS

5.4.7.1 Card Cage

The card cage houses several boards (based on machine configuration). The standard boards used for the V55 are listed below:

PSU B1 board – The PSU (Power Supply Unit) supplies AC and DC voltages to other components of the CNC system. Incoming 200-240VAC is supplied through CP1. The PSU board outputs: 200-240VAC through CP2 and CP3, CONTROL voltage through CP4, and +24VDC through CP5 and CP6.

MAIN CPU board – This is the brain of the machine tool system consisting of ROM modules for controlling:

- CNC operations processing
- Program storage
- Serial communication
- CRT (non graphic) display
- CNC and PMC parameter data
- PMC communication/execution
- Axes Servos
- Serial Spindle Servo
- Manual Pulse Generator (MPG)

OPT3 board – The OPT3 provides the communication link between the CNC unit and the I/O rack. Also used as an RBU (Remote Buffer Unit), and for the CAP (Conversational Automatic Programming) option.

Data Server board – The Data Server board is the communication device between a Host Computer and the CNC. It contains a hard drive for storing CNC programs and also feeds data to the CNC for program execution when the program is to large to be stored in the CNC directory.

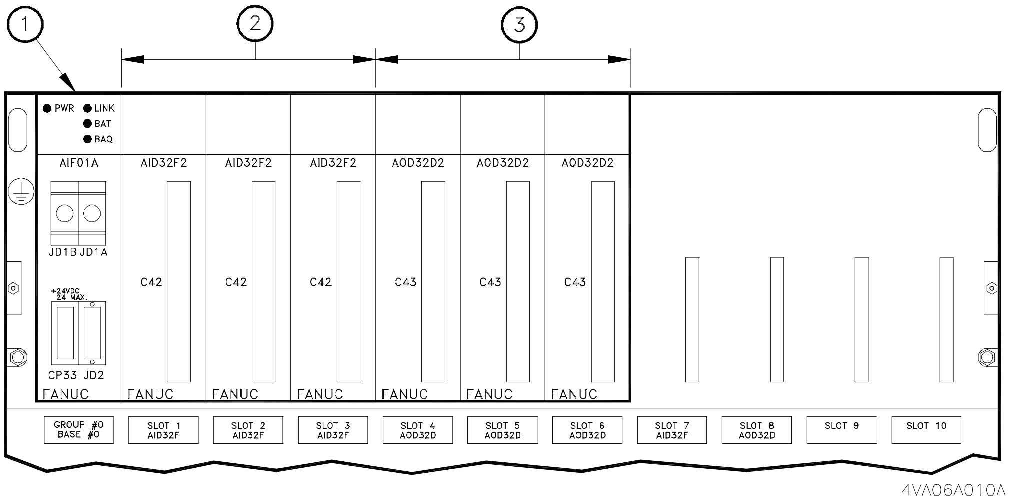
RISC-B board – The RISC-B board is a 64 bit RISC Processor in addition to the standard 32-bit CPU. This provides the necessary throughput for SGI (Super Geometric Intelligence).

More Detail

1. Fusing is provided for current protection, see section 5.4.8.4 (pg 5-40).
2. A lithium battery is used to retain the stored program, parameter, and offset data, see section 5.4.8.3 (pg 5-39).

5.4.7.2 I/O Rack

The I/O (Input/Output) rack (Figure 5-12) is the communication link between the PMC and the MT and is located in the MTC, below the CNC unit. The I/O rack contains several I/O modules (based on machine configuration).



Legend:

[1]	Interface/Power Supply Module	[4]	Module Model N0.
[2]	Input Modules	[5]	Slot No. and Module Model
[3]	Output Modules	[6]	Group and Base No.

FIGURE 5-12 I/O RACK AND MODULES

A V55 with all options (except APC (Automatic Pallet Changer)) has one I/O rack. This rack is named Group#0 and contains eleven slots numbered Group#0, Slot 0 through Slot 10, reading left to right.

A second I/O rack is supplied on machines equipped with an APC. This rack is named Group#1 and contains five slots numbered Group#1, Slot 0 through Slot 4, reading left to right.

Table 5-8 shows I/O module details for Group#0 Base#0 and Table 5-9 shows I/O module details for Group#1 Base#0

TABLE 5-8 GROUP#0 BASE#0 I/O RACK MODULE DETAIL

Group#0 Base#0			
Slot No.	Module Type	Model No.	I/O Address Range
0	Interface/Power Supply -	AIF01A	
1	Input	AID32F2 C42	X00.0 - X03.7
2	Input	AID32F2 C42	X04.0 - X07.7
3	Input	AID32F2 C42	X08.0 - X11.7
4	Output	AOD32D2 C43	Y00.0 - Y03.7
5	Output	AOD32D2 C43	Y04.0 - Y07.7
6	Output	AOD32D2 C43	Y08.0 - Y11.7
7	Input †	AID32F2 C42	X12.0 - X15.7
8	Output †	AOD32D2 C43	Y12.0 - Y15.7
9	Not used		
10	Not used		
† These machines supplied based on machine configuration.			

TABLE 5-9 GROUP#1 BASE#0 I/O RACK MODULE DETAIL

Group#1 Base#0 †			
Slot No.	Module Type	Model No.	I/O Address Range
0	Interface/Power Supply -	AIF01A	
1	Input	AID32F1 C20	X20.0 - X23.7
2	Output	AOD32D1 C41	Y20.0 - Y23.7
3	Not used		
4	Not used		
† Group#1 is provided only on machines equipped with APC (option).			

I/O Rack and the Schematics

In the schematics, references are made to GROUP #n, BASE #0, and SLOT #n. On the V55, these have the following meanings:

GROUP #0	Name of the primary, eleven slot, I/O rack.
GROUP #1	Name of the second, five slot, I/O rack. Supplied on machines equipped with APC.
BASE #0	The BASE number is always “0” for the V55. A BASE number other than “0” references a remote I/O rack.
SLOT #n	The module slot number (location), read from left to right.

Troubleshooting

CAUTION

When Switching Modules

Turn power OFF, before switching modules. Use extreme care when powering ON, as a defective module may have an output stuck ON. This stuck output may cause unexpected motion, which could result in machine damage or personal injury.

When troubleshooting the I/O rack, faulty I/O modules can be isolated by switching “like” modules from one slot to another.

EXAMPLE: A problem with a Slot 2 input is determined. The modules in slots 1 and 2 are the same model and can be switched.

When switching modules n this fashion: 1) turn power OFF before switching module 2) switch only modules with same model No., 3) switch only the module, not the cabling.

If After switching, the slot 2 input problem is corrected and a new problem related to slot 1 shows, up the switched module (now in slot 1) is defective. Check the schematics to see if this input is used in all other modules of this model. If the input is not used switch this module with the defective one and resume normal operation. If the input is used on all modules, replace the module.

5.4.8 Board Level Status/Alarm Display

CNC boards have status and alarm display capabilities, at the component level. These self-diagnostic features are discussed below.

5.4.8.1 Status LEDs

The CNC unit provides several status LEDs to simplify troubleshooting. These LEDs are mounted on the front face of the board (Figure 5-11 (pg. 5-26)).

PIL (Power Indicator Lamp) LED indicates that AC power is supplied to CP1 and serves as a quick checkpoint.

ALM (ALarM) LED lights when overcurrent, over voltage, or low voltage occurs in direct current output voltage.

5.4.8.2 Status/Alarm Displays

Several boards in the CNC Card Cage are equipped with Status and Alarm LED displays. The Status display contains four LEDs that light in different patterns to indicate the status of that board during “start up” and operation. The Alarm display contains three LEDs that light in different patterns to indicate specific alarm conditions. Some of the boards signal alarm conditions by displaying patterns in both the Status and Alarm displays.

On the V55, these CNC boards have Status and Alarm displays:

- MAIN
- OPT3
- DATA SERVER
- RISC-B

Descriptions of their Status and Alarm display conditions follow.

Main Board Status/Alarm Displays

The Status/Alarm display is located on the top face of the MAIN board and consists of two rows of LEDs. The top row (labeled STATUS) indicates CNC startup and operating status. The bottom row (labeled ALARM) displays alarm conditions related to CNC system failures.

STATUS Display – indicates CNC operating status. These green LEDs show the normal ‘boot up‘ process steps and should progress through the steps indicated in Table 5-10.

- If boot up is interrupted, the STATUS LEDs indicate the cause.

ALARM Display – Indicates a system fault, when alarm is displayed on the CRT. These red LEDs show MAIN board alarm conditions, see Table 5-11.

- On the Fanuc 16M (PRO 3), Model C control, system fault conditions are indicated using both the STATUS and ALARM LEDs.

TABLE 5-10 MAIN BOARD NORMAL STATUS DISPLAY AT POWER ON (GREEN LED)

LED Display	Step
□ □ □ □	Power is not turned ON.
■ ■ ■ ■	Software is being loaded into DRAM after power is applied, or CPU fault due to failure.
■ □ ■ ■	Waiting for ID setting for each processor in the system.
□ □ ■ ■	ID setting complete.
■ ■ □ ■	FANUC BUS initialization complete.
□ ■ □ ■	PMC initialization complete.
■ □ □ ■	Initialization of each processor complete.
■ ■ ■ □	PMC ladder initialization complete.
□ ■ ■ □	Waiting for digital servo initialization.
■ □ □ □	Normal operation.
□= OFF ■ =ON	

TABLE 5-11 MAIN BOARD ALARM DISPLAYS (RED AND GREEN LEDS)

LED Display		Alarm Condition
STATUS ALARM	□ ■ □ □ ■ ■ □	RAM parity error is generated on MAIN board.
STATUS ALARM	□ ■ □ □ □ ■ ■	Servo alarm is generated. (watch dog timer alarm.)
STATUS ALARM	□ ■ □ □ □ ■ □	Other system alarm is generated.
STATUS ALARM	■ ■ ■ ■ " ■ "	System stopped before the CPU was activated.
□= OFF ■ =ON "= NO MEANING ❖= FLASHING		

OPT3 Board Status/Alarm Displays

STATUS Display – indicates OPT3 operating status. These green LEDs show the normal ‘boot up‘ process steps and should progress through the steps indicated in Table 5-12.

- If boot up is interrupted, the STATUS LEDs indicate the cause.

ALARM Display – indicates OPT3 fault conditions, see Table 5-13.

- On the Fanuc 16M (PRO 3), Model C control, system fault conditions are indicated using both the STATUS and ALARM LEDs.

TABLE 5-12 OPT3 BOARD STATUS DISPLAY AT POWER ON

LED Display	Step
■ ■ " "	Startup status immediately after power is turned ON.
□ ■ " "	Waiting for each processor to set its ID.
■ □ " "	Waiting for each processor to complete its startup.
□ □ " "	Normal operation - all PMC-RC startup functions completed.
□= OFF ■ =ON "= NO MEANING	

TABLE 5-13 OPT3 BOARD ALARM STATUS

LED Display		Alarm Condition
STATUS ALARM	❖ ❖ " " □ □ □	NMI from another board (LEDs are flashing simultaneously). Check other board LEDs.
STATUS ALARM	□ ❖ " " ■ □ □	Parity error of the memory for Ladder or work. Initialize the memory for the Ladder or replace it for work RAM MODULE.
STATUS ALARM	❖ □ " " □ □ □	Bus error has occurred (incorrect memory access). Replace the OPT3 board.
STATUS ALARM	■ ❖ " " □ □ □	Communication error occurred in the I/O Link. Check the Link device and cables.
STATUS ALARM	❖ ■ " " ■ □ □	Parity error occurred in the PMC control module. Replace the PMC control module.
STATUS ALARM	❖ ❖ " " □ □ □	A checksum error occurred in the system program memory. The DRAM module for the PMC may be faulty.
□= OFF ■ =ON "= NO MEANING ❖= FLASHING		

NOTES:

SKETCHES:

Data Server Board Status/Alarm Displays

STATUS Display – at Power ON – Indicates Data Server board ‘boot up‘ status. These green LEDs show the normal ‘boot up‘ process and should progress through the steps indicated in Table 5-14.

- If boot up is interrupted, the STATUS LEDs indicate the cause.

STATUS Display – Operating Errors – During operation the STATUS displays indicates board and communication errors, see Table 5-15.

- No related alarm is displayed on the CNC or Data Server Message screens.

ALARM Display – indicates Data Server/CNC control alarm conditions, see Table 5-16.

- CNC related alarms are displayed on the CNC Message screen

TABLE 5-14 DATA SERVER BOARD STATUS AT POWER UP

LED Display	Step
□ □ □ □	Power OFF
■ ■ ■ ■	Initial state of power injection
□ ■ ■ ■	Main memory test
■ □ ■ ■	Ethernet RAM test
□ □ ■ ■	Common RAM test
■ ■ □ ■	Initialization of system area
□ ■ □ ■	Fanuc BUS interrupt test
■ □ □ ■	Fanuc BUS interrupt test
□ □ □ ■	Fanuc BUS interrupt test
■ ■ ■ □	Fanuc BUS interrupt test
□ ■ ■ □	Initialization of interrupt controller
■ □ ■ □	Initialization of BIOS
□ □ ■ □	Loading of program to main memory
■ ■ □ □	Completion of system application program
□ ■ □ □	Start of system application program
■ □ □ □	Start of user application program
□= OFF ■ =ON	

TABLE 5-15 DATA SERVER BOARD OPERATING ERRORS STATUS DISPLAY

LED Display		Meaning
Long	Short	
□ □ □ ■	□ □ ■ □	Defect of main memory. Check the PCB.
□ □ □ ■	■ □ ■ □	Defect of ethernet RAM. Check the PCB.
□ □ □ ■	□ ■ ■ □	Defect of common RAM. Check the PCB.
■ □ □ ■	" " " "	Unexpected CPU interrupt. †
□ ■ □ ■	" " " "	Unexpected CPU interrupt. †
■ ■ □ ■	" " " "	Unexpected CPU interrupt. †
□ ■ ■ ■	■ □ □ □	System error in application program. †
□ □ ■ ■	■ □ □ □	Fanuc BUS error. Check other PCB.
□ □ ■ ■	□ ■ □ □	Main memory parity error.
□ □ ■ ■	■ ■ □ □	Ethernet RAM parity error.
□ □ ■ ■	□ □ ■ □	Common RAM parity error.
□ □ ■ ■	■ □ ■ □	Main memory refresh interrupted beyond fixed time.

□= OFF ■ =ON "= NO MEANING Long, indicates a long LED ON/OFF time (slow flash rate) and Short, indicates a short LED on/off time (fast flash rate). The LED flash pattern repeats, until the error condition is corrected.

† Contact your Makino service group.

TABLE 5-16 DATA SERVER BOARD ALARM DISPLAY

LED Display	Alarm Condition
■ □ □	1. Parity error in; main memory, ethernet RAM, or common RAM. 2. Main memory refresh interrupted beyond fixed time, identify cause using Table 5-15.
" ■ "	System error occurred on another PCB. Check status of other PCBs.
" " ■	CPU is in HALT or SHUTDOWN state. Check the PCB.

□= OFF ■ =ON "= NO MEANING

RISC-B Board Status/Alarm Displays

STATUS Display – indicates the RISC-B board operating status. These green LEDs show the normal ‘boot up‘ process and should progress through the steps indicated in Table 5-17.

- If boot up is interrupted, the STATUS LEDs indicate the cause.

ALARM Display – indicates RISC board fault conditions (Table 5-18).

TABLE 5-17 RISC-B BOARD – POWER ON STATUS DISPLAY

LED Display	Step
■ ■ ■ ■	Startup status immediately after power ON or CPU in not running.
□ □ □ ■	DRAM or SRAM test in process. An error keeps LEDs in same state as during test.
□ □ ■ □	ROM test in process. An error keeps LEDs in same state as during test.
■ □ □ □	Waiting for main CPU request (1)
■ □ □ ■	Waiting for main CPU request (2)
■ □ ■ □	Waiting for main CPU request (3)
■ ■ □ □	Waiting for main CPU request (4)
□ □ □ ❖	Waiting for RISC mode to be selected.
□ ❖ □ ❖	Waiting for an NC statement to be entered.
□ ❖ ❖ □	Command being executed in the RISC mode.
❖ □ □ □	Resetting.
❖ □ ❖ ❖	Pre-interpolation ACC/DEC override is 0 (awaiting override level change).
□ □ □ ■	RISC board error during the DRAM or SRAM test.
□ □ ■ □	ROM module test error
□= OFF ■ =ON ❖= FLASHING	

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TABLE 5-17 RISC-B BOARD – POWER ON STATUS DISPLAY (CONTINUED)

LED Display	Step
□ □ ■ ■	A sync signal from the main CPU was not detected.
□ ■ □ □	An error occurred when the F-Bus was accessed.
■ ■ ■ □	System error.
□= OFF ■ =ON ❖= FLASHING	

TABLE 5-18 RISC BOARD – ALARM DISPLAY

LED Display	Alarm Condition
■ □ □	The RISC CPU has not started.
□ ■ □	SRAM parity error.
□ □ ■	DRAM parity error.
□= OFF ■ =ON	

5.4.8.3 Back Up Battery

If the back up battery voltage drops below a specific level, a “LOW BATTERY POWER” alarm is generated.

If power is lost for more than 30 minutes with the low battery or the battery out-of-the-system, data loss may occur.

- Refer to the CNC Maintenance Manual for replacement procedure.

5.4.8.4 CNC and I/O Rack Fuses

Several CNC Card Cage boards and all I/O Rack Modules, have face mounted fusing. Each fuse has an indicator window that displays a white marker, if the fuse has blown.

Table 5-19 lists the CNC fuses, their location and rating, the area protected, and part number.

TABLE 5-19 CNC FUSING CHART

Board Name	Location	Fuse	Rating	Description	Part No.
PSU B1	Front Face	F1	7.5A	200VAC Input	A02B-0200-K101 †
		F3	5AS	9" CRT	
		F4	5A	I/O Unit	
Data Server	Front Face	F1	2A	Board Fuse	A08B-0048-K101
RISC-B	Front Face	F21	5A	Board Fuse	A08B-0048-K101

† This part number is a fuse kit containing all the PSU B1 board fuses.

Troubleshooting

Check all fusing when investigating a fault. Numerous units (like the spindle and axis servo drives) have protective fusing, to protect the component. However, as blown fuses do not typically trigger an alarm learning the location and making a quick visual inspection of all fusing is a good habit to form. See the appropriate section in this Maintenance Guide or refer to the Schematics provided with the machine, for details.

Fuse replacement

If the fuse has failed:

1. Check the circuit to determine the cause and correct it.
2. Turn the AC power source Off, before replacing the fuse.
3. Remove the fuse by pulling straight away from the board face.
4. Insert a new fuse, of the correct rating and type.

NOTES:

SKETCHES:

5.4.9 Axis Servo Components

The CNC controls the axes servo unit forming a true digital servo system, controlling the X, Y, and Z axes and the ATC magazine.

The servo unit (Figure 5-13) consists of; one PSM (Power Supply Module) and four SVMs (Servo Amplifier Modules) – one for each axis (X, Y, and Z) and one for the ATC. All servo modules have the following features to assist in troubleshooting and maintaining the unit.

- Fuse Protection
- PIL and ALM Status LEDs (Power Supply Module only)
- CNC alarm display (CRT display)
- CNC diagnostic status function (CRT display)
- Self-diagnostic display (Servo Drive unit display)
- Built-in circuit breaker

5.4.9.1 PIL and ALM LEDs

The servo drive unit PSM has PIL and ALM LEDs for indicating module status and a 7-segment display, see Figure 5-13.

PIL (Power Indicator Light) LED indicates that power is supplied to the servo drive unit.

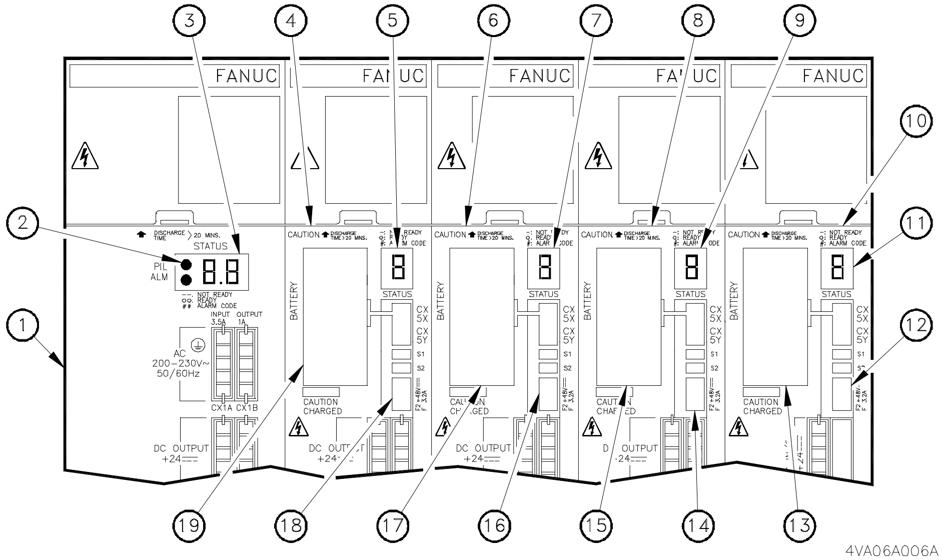
ALM (ALarM) LED indicates that a servo alarm exists.

5.4.9.2 Self-Diagnostic Displays

In addition to the CNC DIAGNOSTIC (SERVO ALARM) and (SERVO STATUS) screens, each servo drive module is equipped with a self-diagnostic display labeled STATUS. These displays are mounted on the face of each module, see Figure 5-13.

Drive status is indicated by a 7-segment STATUS display. The PSM has two 7-segment displays and the amplifier modules have one each. As different conditions occur (within a module) the 7-segment display indicates a number or letter related to the current condition.

- See appendix A for listings of the servo drive alarm conditions.



Legend

[1]	Power Supply Module (PSM)	[11]	Status Display
[2]	PIL and Alarm LEDs	[12]	Fuse
[3]	Status/Alarm Display	[13]	Battery Backup
[4]	X Amplifier Module	[14]	Fuse
[5]	Status Display	[15]	Battery Backup
[6]	Y Amplifier Module	[16]	Fuse
[7]	Status Display	[17]	Battery Backup
[8]	Z Amplifier Module	[18]	Fuse
[9]	Status Display	[19]	Battery Backup
[10]	ATC Amplifier Module		

FIGURE 5-13 AXIS SERVO DRIVE COMPONENTS

5.4.9.3 Axis Servo Drive Fuses

The PSM and each SVM is equipped with a fuse. Each fuse has an indicator window that displays a white marker, if the fuse has blown.

Table 5-19 lists the CNC fuses, their location and rating, the area protected, and part number.

TABLE 5-20 AXIS SERVO DRIVE UNIT FUSING

Module Name	Location	Fuse	Rating Type	Description	Part No.
PSM	Side of Board	F2	2A/250V HM20	Protect Cooling Fan 200VAC Input	A06B-6077-K250 †
		F1	5A/250V HM50	Protect Control Input Power 200VAC	
Amplifier Module	Front Face	F2	3.2A/48V LM32C	Protect Control Power 24VDC	A06B-6073-K250

† This part number is a fuse kit containing all module fuses.

- Refer to the CNC Maintenance Manual for more detail on servo diagnostics.

5.4.10 Spindle Drive Components

The CNC controls the SDU (Spindle Drive Unit) forming a true digital spindle drive system, controlling the V55 spindle.

The SDU (Figure 5-14) consists of; one PSM (Power Supply Module) and one SPM (Spindle Amplifier Module). All SDU modules have the following features to assist in troubleshooting and maintaining the unit.

- Fuse Protection
- PIL and ALM Status LEDs (PSM)
- PIL, ALM, and ERR Status LEDs (Amplifier)
- CNC alarm display (CRT display)
- CNC diagnostic status function (CRT display)
- Self-diagnostic display (SDU display)
- Built-in circuit breaker

See chapter 6 for more information related to the SDU.

5.4.10.1 PIL, ALM and ERR LEDs

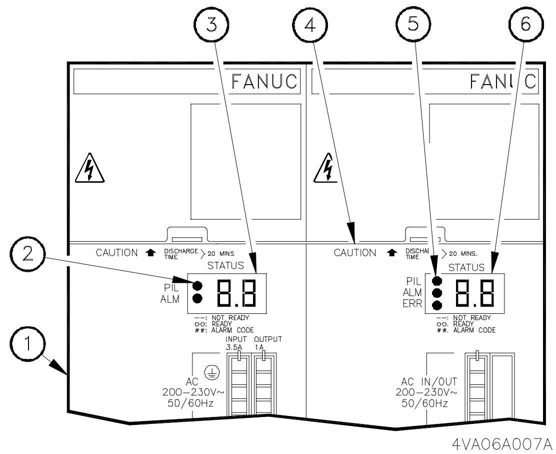
The PSM has PIL and ALM LEDs to indicate status. The amplifier module has PIL, ALM, ERR LEDs to indicate amplifier status. The LEDs are included with the 7-segment display, on both modules, as shown in Figure 5-14.

PIL (Power Indicator Light) LED indicates that power is supplied to the SDU.

ALM (ALarM) LED indicates a SDU alarm condition exists.

ERR (ERRor) LED indicates a SDU error condition exists.

- See appendix A for a listing of SDU related alarm and error conditions.



Legend

[1]	Power Supply Module (PSM)
[2]	PIL and ALM LEDs
[3]	Status Display
[4]	Amplifier Module
[5]	PIL, ALM, and ERR LEDs
[6]	Status Display

FIGURE 5-14 SDU STATUS DISPLAY COMPONEN

5.4.10.2 Self-diagnostic Displays

In addition to the CNC DIAGNOSTIC (SPINDLE STATUS) screen, each SDU module is equipped with a Self-diagnostic display labeled STATUS. These displays are mounted on the individual module faces, see Figure 5-14.

Drive status is indicated by 7-segment STATUS displays. Both spindle drive modules have two 7-segment displays. As different conditions occur (within a module) the 7-segment display indicates a number or letter related to the current condition.

On the Power Supply Module: When the PIL LED is On, power is supplied to module. When the ALM LED is On, the number or letter showing in the 7-segment display represents an Alarm number.

On the Amplifier Module: When the PIL LED is ON, power is supplied to module. When the ALM LED is On, the number or letter showing in the 7-segment display represents an Alarm number. When the ERR LED is On, the number or letter showing in the 7-segment display represents an Error number.

- See appendix A for listings of SDU alarm and error conditions.

5.4.10.3 Spindle Drive Fuses

Both the PSM and SPM are equipped with fuses. Each fuse has an indicator window that displays a white marker, if the fuse has blown.

Table 5-19 lists the CNC fuses, their location and rating, the area protected, and part number.

TABLE 5-21 SDU FUSING

Module Name	Location	Fuse	Rating Type	Description	Part No.
PSM-26 and PSM-30	Side of Board	F2	2A/250V HM20	Protect Cooling Fan 200VAC Input	A06B-6077-K250 †
		F1	5A/250V HM50	Protect 200VAC Control Input Power	
Amplifier Module	Front Face	F2	0.5A/ 250V HM05	Protect Cooling Fan 200VAC Input	A06B-6078-K255 † (14,000 rpm) A06B-6078-K257 † (20,000 rpm)
	Front Face	F1	5A/48V LM50C	Protect Control Power 24VDC	

† This part number is a fuse kit containing all module fuses.

NOTES:

SKETCHES:

5.5 PMC (Machine) Troubleshooting

Details for troubleshooting Machine side faults are presented below. Machine side faults include the MT (Machine Tool) proper and the Custom software of the PMC (Programmable Machine Controller).

Use this information as a guide to the troubleshooting tools provided on the machine tool system and follow the references to other chapters (in this Maintenance Guide) and manuals provided with the machine.

- The Macro Executor generates alarms for most faults on the machine tool. Exceptions to this are power supplies or PMC hardware failures.

5.5.1 Machine Troubleshooting Tools

The troubleshooting tools provided for the machine consist of:

- This Maintenance Guide
- Machine Alarm function
- PMC (Machine and CNC) Diagnostic (I/O) function
- CNC Maintenance Manual
- Schematics

5.5.2 Troubleshooting and the Mechanical Chapters

This Maintenance Guide contains chapters on the mechanical maintenance for each major machine component (unit) and includes the following information and detail:

- Basic principles of operation
- Descriptions of individual mechanisms
- Locations of I/O related components
- Adjustment procedures

5.5.2.1 Mechanical Chapter Format

The mechanical chapters are formatted as follows:

Charts, figure drawings, or tables are placed on the same or facing pages, whenever possible, to eliminate flipping from text to illustration.

When components related to DI/DO signals (limit switches, solenoids, or command signals) are referenced, the PMC address is provided to minimize searching to other pages or chapters.

The PMC address is shown in bold type and parenthesis when located within the text

EXAMPLE: (**X00.1**), (**X00.1 = 1**) or (**CHECK X00.1**)

and may be in parenthesis when presented in a Figure, chart, or Table.

EXAMPLE: (Y208.2)

5.5.3 No Alarm Displayed

If no alarm is displayed, troubleshooting becomes a bit more difficult, but no less logical. If "normal operation" of the machine is not possible and NO alarm is displayed, follow the suggestions provided below.

Always review and understand the events leading up to the current situation. Ask the questions presented in section 5.3 will prove helpful in most situations when NO alarm is displayed.

Considering the number of functions performed by the machine tool, reasons for NO alarm to be displayed are relatively few. A list of common causes, initial checks, and references is provided in Table 5-22.

5.5.4 CRT Does Not Power On

1. Determine if the fault is CNC or Machine side, see section 5.3.
2. If the "side" is not determined, see section 5.4 and section 5.5.
3. If Machine side, see Table 5-22 and start checking voltages.

5.5.5 CRT Is On, And No Alarm Is Displayed

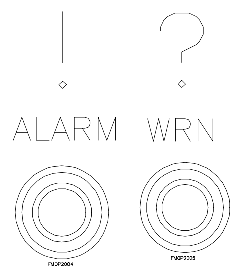
1. Check the CNC DIAGNOSTIC STATUS screen, INTERLOCKS, FEED HOLD, and E-Stop conditions. See section 5.4.5 (pg 5-15).
2. Check Machine Diagnostics (I/O) for machine “ready” conditions (Table 5-22).

TABLE 5-22 COMMON CAUSES WITH NO ALARM DISPLAYED

Cause	Checks	Reference
Electrical Problems	1. Check source voltage at main disconnect (CB0). 2. Check voltage 100H and 100L.	Schematics
CNC Not Ready	1. Check power supply voltages. 2. Check other items in the CNC Maintenance Manual TROUBLESHOOTING section. 3. If control is ready, see Machine Not Ready.	CNC Maintenance Manual
Machine Not Ready	1. Check EMERGENCY signal, switches, relays, and circuits, [*ESP X08.4/G008.4, *ESPA F071.2 and G008.7]. 2. Check NC(PMC) READY signal [MA F001.7]. 3. Check SERVO READY signal [SA F000.6]	Schematics and CNC Maintenance Manual
CNC Internal I/0	1. Check the CNC DIAGNOSTIC STATUS function to see if internal I/O has stopped processing.	section 5.4.5 and CNC Maintenance Manual
CNC/PMC Hardware/ Software Failure	1. Document any abnormal displays or responses. 2. Document program number and function commands involved at fault. 3. Document timing of occurrences. 4. Contact the Makino Customer Support Depart.	Call your Service group
The Machine Not Ready diagnostic signals are vital machine status signals and will prove extremely useful in troubleshooting. If the current state of a PMC address differs from that shown (above), it is probably related to the current fault and should be pursued.		

5.5.6 Alarm Is Displayed

The machine tool system provides an alarm indication for most faults generated on the Machine side. The cause of the fault is provided or “narrowed down” by the displayed alarm description.



Machine alarms are indicated by the red alarm and yellow warning status lamp (on the Main Operation Panel).

- The Custom - ALARM screen is not automatically displayed.

If the alarm or warning status lamp lights:

1. Display the Custom - ALARM screen, see section 5.5.7 and read the alarm message area.
2. Check the related I/O devices and correct the fault. See appendix B.
   A. Refer to the appropriate mechanical chapters for detail on principles of operation, adjustments, etc.
   B. Use the Maintenance mode for recovery of ATC and APC (option) faults. See section 5.5.10 for an overview of the Maintenance mode and the appropriate mechanical chapter for specifics.

Alarm Detail

The ALARM screen provides more detail about the current alarm condition than the alarm listing in appendix A.

5.5.7 Custom Side Alarm Display

Custom side or machine alarms are of two (2) types; Alarms and Warnings.

- Alarms are faults causing a halt in operations
- Warnings are conditional alerts affecting operation or needs attention, before it becomes an alarm.

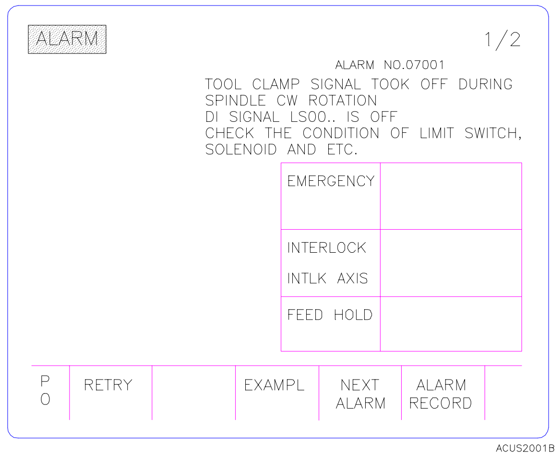


FIGURE 5-15 PRO A ALARM SCREEN

When a machine alarm occurs:

- The machine alarm or warning LED lights.

1. Press the [CUSTOM] function key.
2. Press the [PO] softkey (if the PO screen is not displayed).
3. Press the [MS] softkey, to display the [ALARM] softkey.
4. Press the [ALARM] softkey to display the ALARM screen.
   - Information displayed on the screen gives the required alarm detail.

Screen Display

Key ALARM screen (Figure 5-15) display details are:

PAGE NUMBERS – the number of pages varies with the number of active alarms (1/1 = 1 alarm, 1/2 = 2 alarms, etc.). Press [NEXT ALARM] to display the next page.

ALARM NUMBER – displayed below the page numbers.

MESSAGE AREA – below the ALARM NUMBER, this area consists of the Error Message, Signal Name, and Recovery Procedure.

ERROR MESSAGE – provides a short explanation of the events generating the alarm.

SIGNAL NAME – indicates the input signal or limit switch which has generated the alarm.

RECOVERY PROCEDURE – presents a recovery procedure for alarms requiring more than just a simple [RESET].

Softkey Menus

[RETRY] – Displayed only when the RETRY function is possible. RETRY allows resuming an interrupted automatic sequence, after the fault is corrected.

[EXAMPL] – Displays several “sample” ALARM screens. Step through the samples by pressing [EXAMPL].

[NEXT ALARM] – Displays additional alarms when pressed.

[ALARM RECORD] – Displays the ALARM RECORD screen. See section 5.5.7.1.

To abort an interrupted automatic sequence, press [ALARM RESET] on the operation panel.

5.5.7.1 Custom Alarm Record Display

The ALARM RECORD screen provides a record of the last twenty PMC alarms (Figure 5-16).

Press the page [↑] / [↓] keys to move through the ALARM RECORD screen.

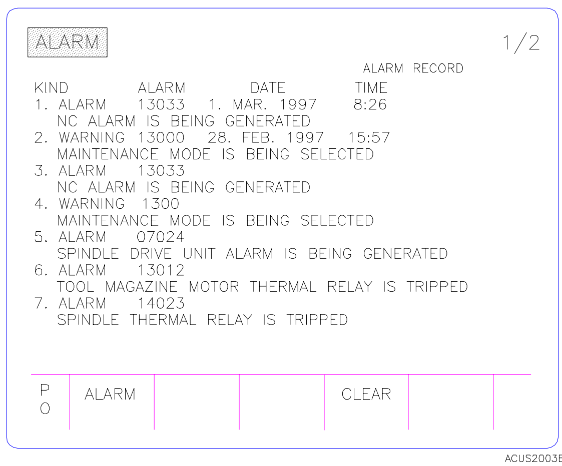


FIGURE 5-16 PRO A ALARM RECORD

Screen Display

Each alarm record consists of the kind of alarm (alarm or warning), alarm number, the date (year/month/date), the time (military time), and a brief error message.

- The first alarm record on page 1 is the most recent alarm, and the last alarm on page 4 is the oldest alarm.

Softkey Menus

The softkey menus for the ALARM RECORD screen are described below.

[ALARM] – Displays the ALARM screen.

[CLEAR] – Clears or deletes all alarm records on the screen.

5.5.8 Primary Operation (PO) Screen

The PO (Primary Operation) screen is the initial Custom side display. This screen provides; access to all other Custom screens and an overview of the machine's current operating condition or MACHINE STATUS. Figure 5-17.

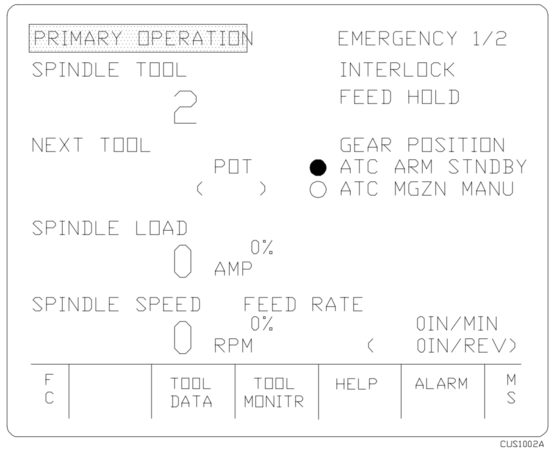


FIGURE 5-17 PO SCREEN

To display the PO screen:

1. Press the [CUSTOM] function key.
2. Press the [PO] softkey (if the PO screen is not displayed).

5.5.8.1 Machine Operating Status

The right side of the screen displays MACHINE STATUS: ATC STANDBY and MANUAL INTERRUPT conditions, gear range, and machine MAINTENANCE conditions. At a glance one can determine:

STANDBY conditions exist or not?

- If STANDBY conditions are NOT present, see Standby Conditions (pg 5-57).
- To recover STANDBY use Maintenance mode, section 5.5.10.

ATC MANUAL INTERRUPT status.

- If the ATC MANUAL indicator is active, check the condition (On/Off) of the[MANUAL INTERRUPT] button on the ATC Operation Panel.

Current machine MAINTENANCE conditions:

- EMERGENCY
- INTERLOCK
- FEED HOLD

If any of these conditions are highlighted, go to the MAINTENANCE screen menu page, see section 5.5.10 for more detail.

Standby Conditions

To prevent personal injury and machine damage, the PMC must “know” that the ATC (Automatic Tool Changer) and APC (Automatic Pallet Changer) are in a safe position before allowing automatic operation. This safe position is called the STANDBY condition.

- If STANDBY is lost, an INTERLOCK is issued to prevent axis movement.

See the appropriate mechanical chapter more detail on STANDBY.

5.5.9 Custom Diagnostic Display

PMC diagnostics are useful in troubleshooting the CNC, PMC, and the MT. Diagnostics allow you to see the current state (On/Off) of specific I/O signals, as viewed by the PMC.

The PMC is the origin of system communication and must see proper signal conditions to continue program processing. This makes the PMC diagnostics a key starting point in troubleshooting most MT system faults.

- See section 5.6 for more detail on this important troubleshooting tool.

5.5.10 Maintenance Screens

Makino's custom side MAINTENANCE screen provides two machine status and maintenance related functions.

- MAINTENANCE MENU page, provides detail on the current status of EMERGENCY, INTERLOCK, FEED HOLD, and SERVO OFF conditions, as shown in Figure 5-18 and discussed in section 5.5.10.1.
- Maintenance mode, which allows for safe step-by-step actuation and recovery of the ATC or APC and is discussed in section 5.5.10.2.

To display the MAINTENANCE screens:

1. Pressing [CUSTOM] function key. Press the [PO] softkey (If the PO screen is not displayed).
2. Press the [MS] softkey, to display the [MAINTENANCE] softkey.
3. Press the [MAINTENANCE] softkey.
4. Use the page [↑]/[↓] keys to toggle between the two pages.

5.5.10.1 Maintenance Menu

Like the maintenance area on the PO screen (section 5.5.8.1) machine status is displayed on the MAINTENANCE MENU page. Machine status conditions are divided into four groups, shown in Figure 5-18:

- EMERGENCY – The item and cause are shown in red when an E-STOP condition exists.
- INTERLOCK – The item and cause are shown in yellow when an INTERLOCK condition exists.
  - INTERLOCK AXIS – The INTERLOCKED axis is shown in yellow.
- FEED HOLD – The item and cause are shown in yellow when a FEED HOLD condition exists.
- SERVO OFF – The item and cause are shown in green when a SERVO OFF condition exists.

When one of these groups is “active,” the group name is highlighted, and related conditions are displayed.

Order of Operation

1. Not all status conditions indicate a fault; some INTERLOCK, FEED HOLD, and SERVO OFF conditions are “normal” during machine operation.
2. MENU page layout and data are arranged in descending order. For example, an EMERGENCY condition causes INTERLOCK, FEED HOLD, and SERVO OFF conditions. Start at the top of the screen. Correcting the EMERGENCY condition first should clear all other related status conditions.

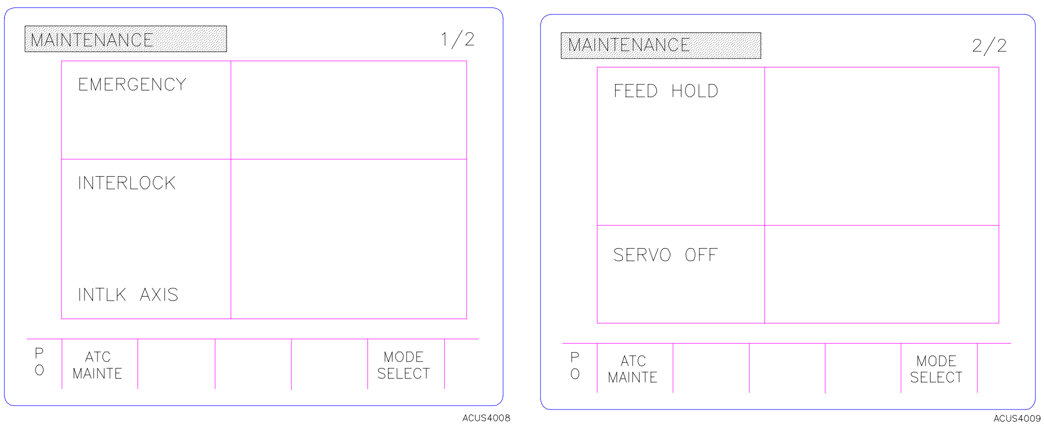


FIGURE 5-18 MAINTENANCE MENU PAGES

Softkey Menus

The menu page soft menu selection are related to the MAINTENANCE mode

[PO] – Displays to the PO screen.

[ATC MAINTE] – Displays the ATC maintenance screen.

[MGZ MAINTE] – Displays the ATC magazine maintenance screen.

[MODE SELECT] – Activates and deactivates the Maintenance mode, see section 5.5.10.2.

5.5.10.2 Maintenance Mode

The Maintenance mode provides access to ATC, ATC magazine "automatic" operations. Maintenance mode allows step-by-step control of ATC related operations.

- This function is useful for setup, adjustment and alignment of ATC components, and recovery of an interrupted automatic action.

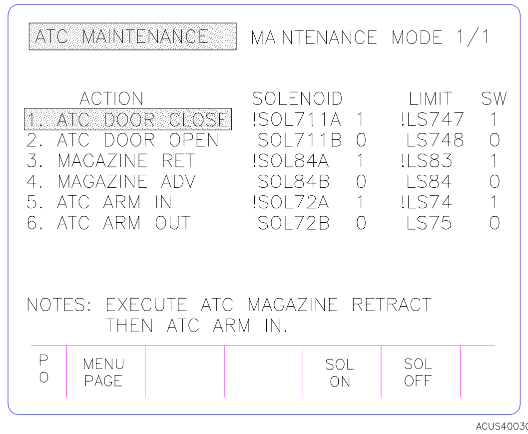


FIGURE 5-19 ATC MAINTENANCE SCREEN

Screen Display

The following items are displayed on the ATC MAINTENANCE screen. (Actual screen content (action steps) varies based on the ATC (option) provided.)

MAINTENANCE MODE – Indicates the Maintenance mode is active.

ACTION – Lists steps of ATC motion (based on ATC type).

SOLENOID – Lists solenoid and current output status (1= On and 0=Off).

LIMIT SW – Lists limit switch and current input status (1= On and 0=Off).

- SOL and LS designations preceded by and exclamation mark (!) indicate the conditions needed for STANDBY.

Softkey Menus

Maintenance mode active:

[MENU PAGE] – Displays to the maintenance MENU page to activate/ deactivate Maintenance mode or return to the PO screen.

[SOL ON] – Energizes the solenoid related to the selected action.

[SOL OFF] – Deenergizes the solenoid related to the selected item.

Maintenance mode inactive

[MENU PAGE] – to activate/deactivate Maintenance mode or return to the PO screen.

Basic Operation Sequence

When using maintenance mode proceed as follows:

1. Display the MAINTENANCE screen MENU page.
2. Activate Maintenance mode. Press [MODE SELECT].
3. Press [ATC MAINTE] or [MGZ MAINTE], based on ATC unit and current requirements.
4. See the ATC chapter for detail on ATC sequence and recovery procedures.
5. Use the cursor [↑] / [↓] keys to move the screen cursor to the required action (sequence step).
6. Press the [SOL ON] or [SOL OFF] softkey, to initiate the selected action.

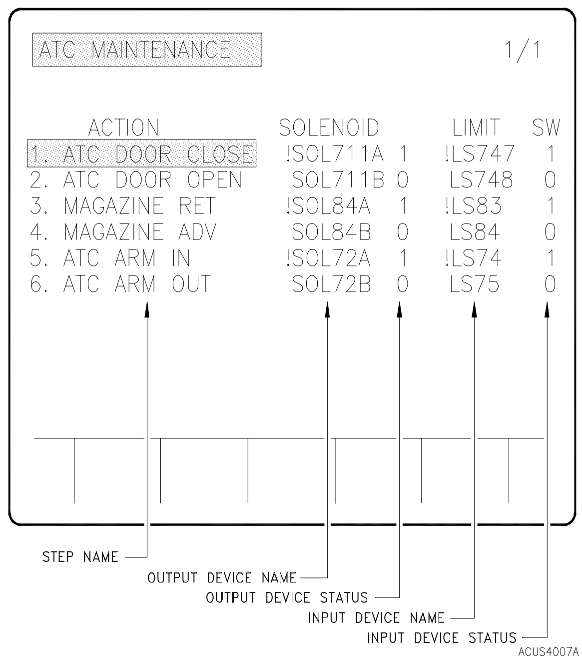


FIGURE 5-20 ATC MAINTENANCE SCREEN DETAIL

Operational Detail

For more detail on Maintenance mode see the applicable mechanical chapter.

1. If a selected “step” is out of sequence, the action may not occur. Software INTERLOCKS prevent such action to avoid personal injury or damage to the machine.
2. If a selected “step” does not occur, check the Custom alarm screen. The out of sequence condition will be explained.
3. Some situations require that software INTERLOCKS be overridden to recover the unit's operating condition. INTERLOCKS are overridden by pressing and holding the [OT RELEASE] button, on the operation panel and pressing [SOL ON].
4. If one of a pair of solenoids is energized, the other is automatically deenergized.

5.6 Diagnostic I/O Function

The diagnostic function is a powerful troubleshooting tool and should serve as one of the first stops in diagnosing any system fault.

PMC diagnostics consist of the DI and DO signals used in communication between the CNC (Computerized Numerical Controller), PMC (Programmable Machine Controller), and the MT (Machine Tool).

A diagnostic display is provided on both the CNC and Custom side of the system. Both functions provide the same data although there are some format differences.

Makino developed its diagnostic display to provide enhanced capability and recommends using the Custom side diagnose screen for troubleshooting.

- The CNC diagnostic function display is discussed briefly in section 5.6.2. For more detail on the CNC diagnostic display, refer to the CNC Operator Manual.
- The Custom diagnostic function is discussed in section 5.6.3.
    - We recommend using the Custom side diagnostics and refer to this diagnostic function in all discussion on diagnostics.

5.6.1 Diagnostic Basics

Like the rest of the system we can divide the diagnostics into two types or sides:

CNC to PMC

Generally, there is little need to pursue specific CNC to PMC communication (F and G) signals:

Communication is transmitted on the F-BUS (Fanuc Bus). The F-BUS is a common bus on a control. Hardware failures on the CNC to PMC link are rare. CNC/PMC software is very stable and software problems cause “system” type errors. Software problems are not effectively traced using PMC diagnostics.

The PCBs (Printed Circuit Boards) are dependable and failures or faults rare. PCB faults affect more than single or isolated signals. Of the main components of the CNC ↔ PMC side of the system PCB faults are most likely.

PMC to MT

The I/O signals between the PMC to MT (X and Y) are those most commonly checked through the PMC diagnostics:

Inputs (X) determine if the PMC is receiving proper information. Is the limit switch On/Off? Is the UNCLAMP button working?

Outputs (Y) show if the PMC is issuing a command to generate an action. Is the solenoid energized? Is DRY RUN On?

Failure of input or output devices on the I/O board is rare but may cause a fault. In this case PMC diagnostics can be used to indicate:

1. The output signal controlling a particular action has been generated, when the action has not physically occurred.
2. An incoming signal, like a limit switch confirming an action, does not pass beyond the I/O to the PMC and processing is halted.

If the PMC is sending but not receiving the proper I/O signals look at the machine side components (limit switches, solenoids, etc.) **FIRST**!

If machine components check good, then pursue voltage between the I/O board and the component, to isolate the fault to the I/O board.

5.6.2 CNC Diagnostic (I/O) Display

CNC diagnostics or PMC SIGNAL STATUS screen displays the MT system I/O communication signals, as viewed by the PMC.

Signals are organized and searched by their PMC address and prefix (F, G, X, and Y).

- A listing of the CNC to PMC (F and G) is located in the CNC Maintenance Manual, (use the M series interface).
- PMC to MT (X and Y) I\O signals are provided in appendix B.

PMC SIGNAL STATUS

ADDRESS	7	6	5	4	3	2	1	0
G0000	0	0	0	0	0	0	0	0
G0001	0	0	0	0	0	0	0	0
G0002	0	0	0	0	0	0	0	0
G0003	0	0	0	0	0	0	0	0
G0004	0	0	0	0	0	0	0	0
G0005	0	0	0	0	0	0	0	0
G0006	0	0	0	0	0	0	0	0
G0007	0	0	1	0	0	0	0	0

(SEARCH)( )( )( )( )

CNC6007A

FIGURE 5-21 CNC SIDE PMC SIGNAL STATUS SCREEN

To display the PMC diagnostics:

1. Press the [SYSTEM] function key.
2. Press the [PMC] softkey.

PMC Signal Status Search

To search a specific diagnostic address (PMC address):

1. Key in the desired PMC address, (example: Y100.0).
2. Press the [SEARCH] softkey.

5.6.3 Custom Diagnostic (I/O) Display

Custom diagnostics are viewed on DIAGNOSE screen (Figure 5-22).

The DIAGNOSE screen contains 40+ pages displaying the status (ON/OFF) of input and output signals used in the communication among the CNC, PMC, and MT.

This screen is designed as a split screen, with inputs (DI) on the left and outputs (DO) on the right. Allowing the user to display related inputs and outputs for simultaneous viewing.

To display the DIAGNOSE screen:

1. Press the [CUSTOM] function button.
2. Press the [PO] softkey (if PO screen is not displayed).
3. Press the [MS] softkey to display the [DIAGNOSE] softkey.
4. Press the [DIAGNOSE] softkey.

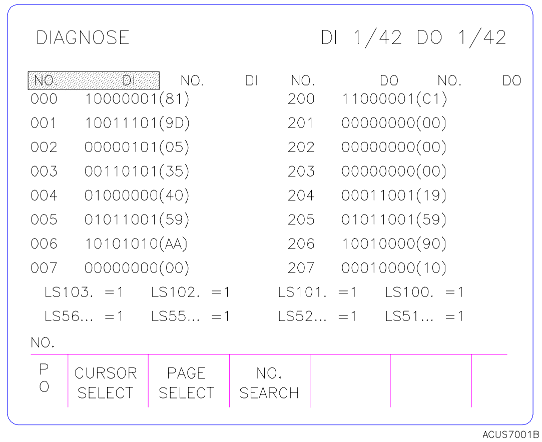


FIGURE 5-22 DIAGNOSE SCREEN

Screen Display

No. – The I/O address numbers for the I/O signals are displayed.

DI or DO– Identifies the DI and DO sides (pages) of the screen. The active page is highlighted by the page cursor.

The 8-bit diagnostic display is located under the DI or DO heading. Additionally a hexi-decimal total of the 8-bit status is provided in parenthesis.

Signal area – Displays the signal name and state for each data bit in the selected address. Bit 0 - 3 are on the bottom row starting with 0 on the right. Bit 4 - 7 are on the top row starting with 4 on the right, as shown below.

bit 7 _ LS82..=1 LS81..=0 LS77..=1 LS76..=0 _ bit 4

bit 3 _ LS75..=0 LS74..=1 LS01..=0 LS00..=1 _ bit 0

Softkey Menus

[PAGE SELECT] – Selects the active page (DI or DO) and determines which side of the screen is accessed by [NO. SEARCH] or page key operations.

[NO. SEARCH] – Searches a specific I/O address number. To search an I/O address:

1. Press [PAGE SELECT] to shift the cursor to the DI or DO page.
2. Using the numeric keys, key in the I/O address number to be searched.
3. Press the [NO. SEARCH] softkey.

5.7 Schematic Overview

Electrical Hazard

DANGER

As in all electrical/electronic devices, the potential for electrical shock exists. Use extreme care when troubleshooting electrical problems on the machine tool. The information provided in this chapter is presented to assist qualified electrical technicians **ONLY!** It is not intended and should not be construed as a training course on basic electricity or electronics.

A set of electrical drawings (schematics) are provided with the machine. The schematics are stored in a pocket on the MTC (Machine Tool Cabinet) door.

The schematic drawings are not machine specific, but are “master” drawings and include the drawings for all currently available machine configurations.

This chapter provides information to assist maintenance personnel, trained in working with electricity, to better understand the page lay out, symbols and conventions used in these schematics.

Information Subject to Change

Every effort was made to ensure the accuracy of the data presented in this chapter at the time of publication. However, machine and control specifications are subject to change without prior notification.

Description

The schematic drawings are not machine specific, but are master drawings and include the drawings for all currently available machine configurations.

Examples of the following drawings are included in this section.

- RECORD OF MAINTENANCE DRAWINGS - Drawing No. TEC02-0101R110 lists the date of the original drawing and the revisions to all drawings, see Figure 5-23.
- CONTENTS - Drawing No. TEC02-0101E110 lists the drawings by circuit name, drawing number, and pages, seeFigure 5-24 for an example of this drawing.
- WIRING MATERIAL APPLICATION TABLE - Drawing No. TEC02-0101E140 lists the wiring and applications where the wiring is used, see Figure 5-25 for an example of this drawing.

5.7.1 The Title Page

The first drawing is the title page. This page includes the:

- Drawing set name - V55 CONTROLLER, MAINTENANCE DRAWINGS
- Machine identification number - UNIT No., TEC02
- Drawing edition number - EDITION No., 00-3
- Title page drawing number - TEC02-0101E100.

5.7.2 Record of Maintenance Drawing

Figure 5-23 (pg. 5-68) shows the contents of the record and section 5.7.2.1 identifies the entries.

5.7.2.1 Record of Maintenance Drawing Detail

EDITION No. – the edition number for this set of V55 CONTROLLER MAINTENANCE DRAWINGS.

VERSION – the version (or revision level) of this edition.

SEQUENCE – the number symbol of the change applied to the indicated drawing. The symbol is put on the drawing where the change was made.

DATE – date change was generated (yy.mm.dd format).

DRAWING INFORMATION No. – number of drawing detailing specifics relative to the drawing change.

CONTENT – the change made to the drawing.

CHANGE DRAWING No. – the drawing and page number affected by the change.

RELATED INFORMATION No. – reference to other documents that may be available relative to the drawing change.

RECORD OF MAINTENANCE DRAWING

EDITION No.	VERSION	SEQUENCE	DATE	DRAWING INFORMATION No.	CONTENT	CHANGE DRAWING No.	RELATED INFORMATION No.
00	0		97.10.13	--------	THE FIRST EDITION	-------	
	1	1	97.12.01	æ	CHG. FUSE ADDRES	TEC02-0101E200-1	
		1	97.12.01	æ	CHG. FUSE ADDRES	TEC02-0101E200-131	
		1	97.12.01	E4V-0177	CHG. LS99	TEC02-0101E200-272	
		1	97.12.01	E4V-0177	CHG. LS99	TEC02-0101E200-274	
		1	97.12.01	E4V-0177	CHG. LS99	TEC02-0101E200-275	
		1	97.12.01	E4V-0177	CHG. LS99	TEC02-0101E300-11	
		1	97.12.01	E4V-0177	CHG. LS99	TEC02-0101E350-7	
		1	97.12.01	E4V-0177	CHG. LS99	TEC02-0101E500-9	
		1	97.12.01	E4V-0177	CHG. LS99	TEC02-0101A130	
		1	97.12.01	E4V-0177	CHG. LS99	TEC02-0101A230	
	2	1	97.12.01	E4V-0238	CHG. L/C	TEC02-0101E200-33	
		1	97.12.01	E4V-0238	CHG. L/C	TEC02-0101E200-36	
		1	97.12.01	E4V-0238	CHG. L/C	TEC02-0101E200-152	
		1	97.12.01	E4V-0238	CHG. L/C	TEC02-0101E200-411	
		1	97.12.01	E4V-0238	CHG. L/C	TEC02-0101E300-2	
		1	97.12.01	E4V-0238	CHG. L/C	TEC02-0101E300-17	
		1	97.12.01	E4V-0238	CHG. L/C	TEC02-0101E500-7	
	3	1	98.02.19	E4V-0277	ADD. LS1339	TEC02-0101E200-251	
		2	98.02.19	E4V-0277	ADD. LS1339	TEC02-0101E300-2	
		1	98.02.19	E4V-0277	ADD. LS1339	TEC02-0101E350-1	
		1	98.02.19	E4V-0277	ADD. LS1339	TEC02-0101E350-3	
		1	98.02.19	E4V-0277	ADD. LS1339	TEC02-0101E400-2	

FIGURE 5-23 RECORD OF MAINTENANCE DRAWING EXAMPLE

5.7.3 Contents

Figure 5-24 provides an example of SHEET 1 of the CONTENTS drawing.

CONTENTS

CONTENT			DRAWING NO.	PAGE
OPTION TABLE			TEC02-0101E120	1
CONNECTION			TEC02-0101E130	1~5
WIRING MATERIAL APPLICATION TABLE			TEC02-0101E140	1~4
REMARK			TEC02-0101E150	1
CIRCUIT	INPUT POWER SOURCE	MAIN POWER · H&H COOLANT · EXTERNAL TRANSFORMER	TEC02-0101E200	1
		EARTH LEAKAGE PROTECT		2
		BREAKER CIRCUIT · MTC 100V RECEPTACLE & ILLUMINATION		3
	SPINDLE SERVO	POWER SUPPLY MODULE · SERVO AMP MODULE		11
		SIGNAL CABLE		12
		SPINDLE ROTOR CHANGE		13
	FEED AXIS ATC MAGAZINE AXIS SERVO	4 TH - AXIS SERVO MODULE		20
		POWER SUPPLY MODULE · X, Y, Z – AXIS SERVO AMP MODULE		21
		ATC – AXIS SERVO AMP MODULE		22
		ATC A, B – AXIS SERVO AMP MODULE		23
		POWER SUPPLY MODULE		24
	BRAKE	SERVO MOTOR BRAKE		25
		ATC SERVO MOTOR BRAKE		26
	MOTOR DYNAMIC FORCE	HYDRAULIC UNIT · NOZZLE COOLANT · SCRAPPER CONVEYOR		31
		SPINDLE LUBRICANT · BALL SCREW QUILL · SPINDLE OIL TEMP.		32
		LIFT UP CHIP CONV. · FILTER OPPOSITE FLOW CLEANING CEILING SHOWER COOLANT · WORKPIECE WASHING GUN		33
		THROUGH SPINDLE · THROUGH TOOL · OIL MIST COLLECTOR		34
		COOLANT OIL TEMP. CONTROLLER		35
		THERMAL RELAY SETTING TABLE		36
		FAN MOTOR		51

FIGURE 5-24 CONTENTS DRAWING EXAMPLE

5.7.3.1 Contents Detail

The schematic content pages (Drawing No. TEC02-0101E110) are on drawing sheets. Column headings indicate the drawing name (CONTENT), number (DRAWING No.), and number of pages or page of a sub-circuit (PAGE). The entries at the top of SHEET 1 are explained below.

OPTION TABLE – lists the name, drawing number and related pages in that drawing where the option circuitry is shown.

CONNECTION – system block diagram showing major interconnections.

WIRING MATERIAL APPLICATION TABLE – lists the schematic wires and cables by circuit(s), use, type of connections, wiring material and size, and flags. Figure 5-25 shows an example of the table.

REMARK - when supplied, this drawing provides remarks related to the edition and version of the set of drawings.

CIRCUIT – lists major circuits (Table 5-23) with the sub-system names or description, drawing numbers, and page numbers (SHEET No. on the drawing) in the adjacent columns. The major circuits (in alphabetical order) in the V55 CONTROLLER MAINTENANCE DRAWINGS are:

TABLE 5-23 MAJOR CIRCUITS

4TH AXIS	JOINT BOX ASSEMBLY
APC	LIFT UP CHIP CONVEYOR OPE PANEL
APC CONTROLLER	MACHINE LIGHTING
ATC	MEASURING
AUTO GREASE INJECTOR	MOTOR DYNAMIC FORCE
BRAKE	NC POWER SOURCE
CONTROL CIRCUIT	OPE. PANEL ASSEMBLY
CONNECTOR TABLE	OPERATOR’S PANEL
DI/DO ADDRESS TABLE	PARTS LIST
DIMENSION OF CABINET	S/G WIPER
DOOR INTERLOCK	SIGNAL LIGHT
FEED AXIS ATC MAGAZINE AXIS SERVO	SPECIAL SPECIFICATION
HOUR METER	SPINDLE SERVO
INPUT POWER SOURCE	TERMINAL TABLE
INSTALLATION DRAWING OF CABINET	

5.7.4 Wiring Material Application Table

Figure 5-25 provides an example of SHEET 1 of the WIRING MATERIAL APPLICATION TABLE drawing.

SPECIFICATION		SIGNAL NAME	CONNECTION	WIRING MATERIAL	
POWER SOURCE	AC200/220V	R, S, T U, V, W 200A, B ETC.	TERMINAL ~ TERMINAL	MFLC 60mmsq BLACK MFLC 38mmsq BLACK MFLC 22mmsq BLACK MFLC 14mmsq BLACK MFLC 5.5mmsq BLACK MLC 2mmsq BLACK	BL
				IV 2mmsq BLACK	BL
				KIV 1.25mmsq RED	RD
	AC100/110V	100H 100L ETC.	TERMINAL ~ TERMINAL LAPPING LAPPING	KIV 1.25mmsq RED LAPPING 0.1mmsq RED	RD RD
	AC20V	T24H T24L	TERMINAL ~ TERMINAL	KIV 2mmsq RED	RD
	AC21V	R324H R24L			
CONTROL CIRCUIT	DC90V	D90H D90L ETC.	TERMINAL TERMINAL FASTEN ~ FASTEN SOLDER	KIV 1.25mmsq BLUE	BU
	DC24V	R124H C24H,L Y24H A24H P24H	TERMINAL FASTEN TERMINAL SOLDER ~ SOLDER LAPPING LAPPING CONNECTOR CONNEC-TOR	KIV 2mmsq BLUE KIV 1.25mmsq BLUE	BU
				LAPPING 0.18mmsq BLUE LAPPING 0.1mmsq BLUE	BU
				PLATING WIRE	WIRE

FIGURE 5-25 WIRING MATERIAL APPLICATION TABLE EXAMPLE

5.7.4.1 Wiring Material Application Table Detail

SPECIFICATION. – provides the circuits and voltage (SHEET 1 only) where the wiring is used.

SIGNAL NAME – lists the signal names carried on the wiring.

CONNECTION – shows the type of connectors.

WIRING MATERIAL. – presents the type, size and color coding, used for the wiring.

5.8 Schematic Interpretation

This section presents two different schematic page examples. Explanations and specific detail on annotations, symbols, names, and other conventions used in the schematics follow each example.

- Zone locators are provided across the top and bottom and down both sides of each schematic sheet. The numeric locators, 1 through 7, are at the top and bottom of each sheet and the alpha locators, A through E, are place along the sides of each sheet.
- When a circuit is continued on, or from, another sheet, reference to its location is made by a notation like 200/1A. This means that the circuit can be picked-up on Sheet 200, Zone 1A.

5.8.1 Page Format

A key to the locating system used in the schematics is to become familiar with the conventions used in the drawings to streamline and simplify your troubleshooting.

- Figure 5-26 shows the general lay out and page format used in the schematics.

Zones – The numbers on the top and bottom of the sheet (1 through 7) and letters on the left and right sides (A through E) are the zone locators for individual devices, connectors, lines, etc.

Legend Area – The legend area of each drawing contains page/sheet number, circuit/drawing title, drawing number, and revision area.

Sheet/Page Number – Page/sheet numbers are in the bottom right corner of the page. A page number/number of pages format (001/--) is used: however, the total number of pages are not listed.

Circuit/Drawing Title – The circuit/drawing title is listed in the CONTENTS beside or under the CIRCUIT column. It identifies the area or circuit shown by the drawing.

Drawing Number – The drawing number is assigned to the major circuit for the machines.

Revision Area – The revision area lists all revision made to the page/sheet.

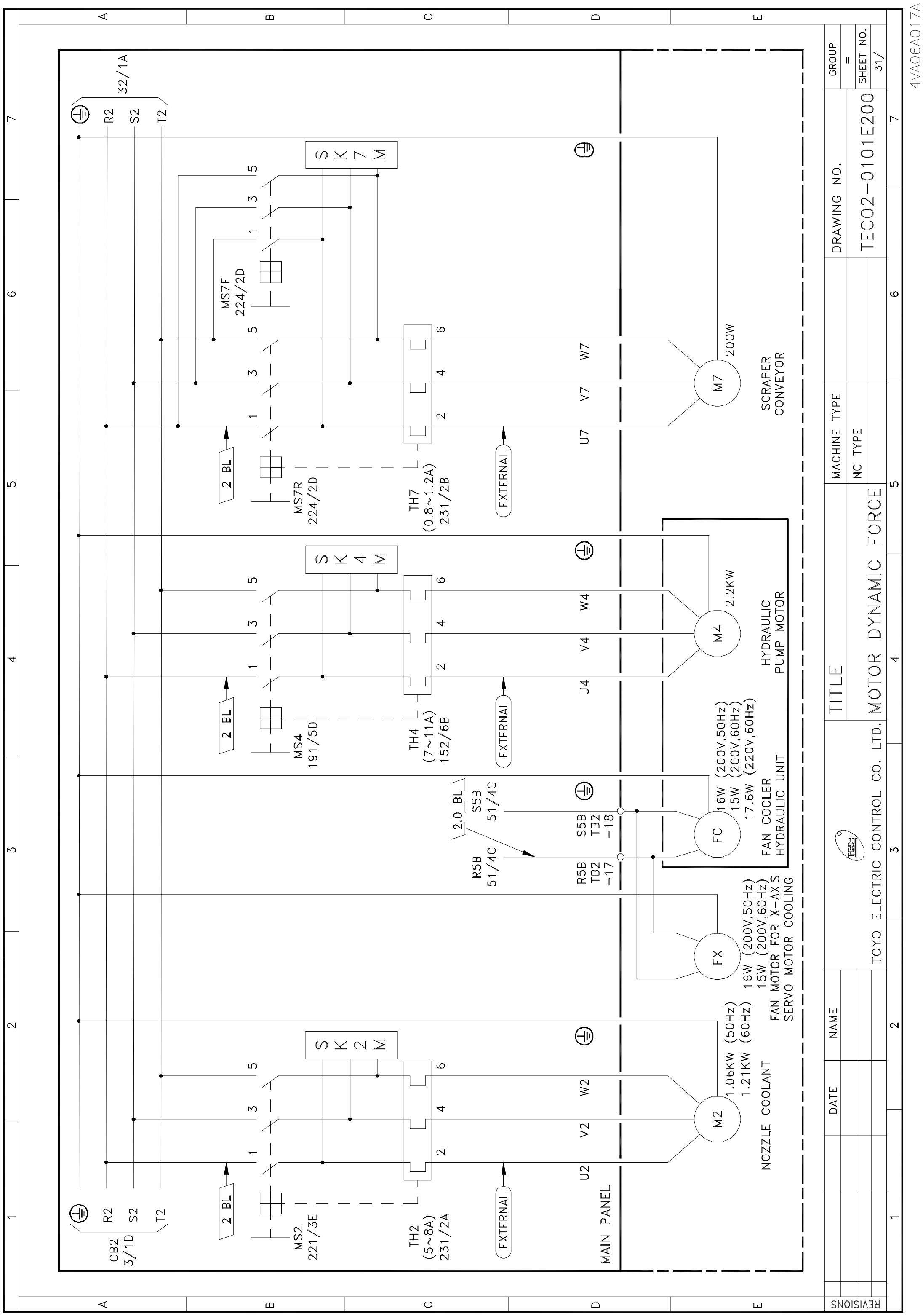


FIGURE 5-26 SCHEMATIC PAGE FORMAT

5.8.2 Example 1

Figure 5-27 shows a portion of the MOTOR DYNAMIC FORCE drawing, Sheet 31, of Drawing No. TEC02-0101E200. This example shows Zones 1A through 2E.

Example 1 Detail

Table 5-24 provides an explanation of the symbols, device names and location techniques used in Example 1 (Figure 5-27)

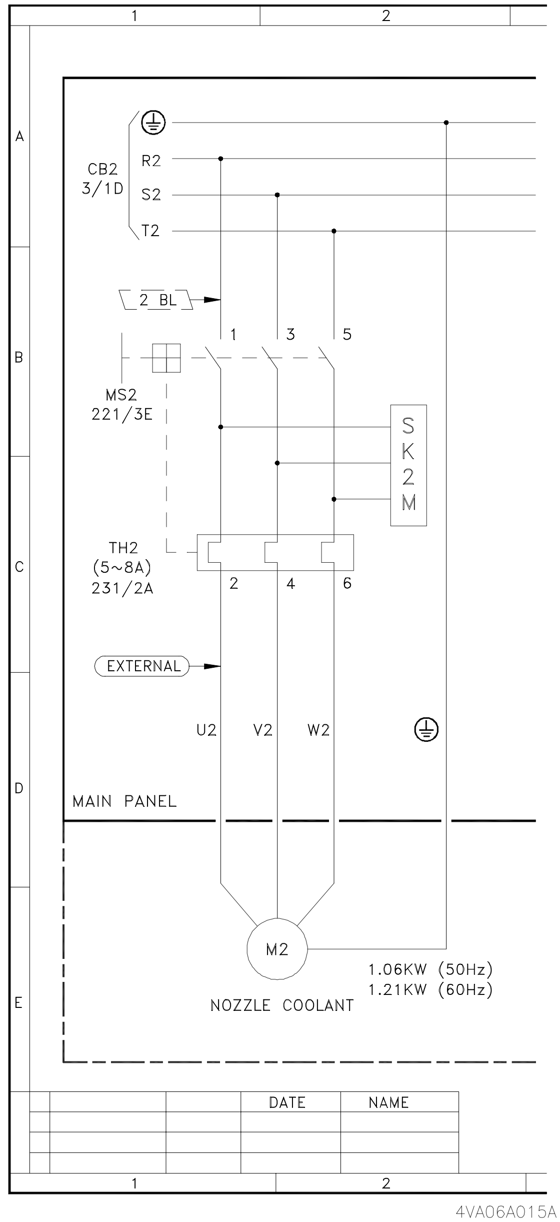


FIGURE 5-27 SCHEMATIC INTERPRETATION EXAMPLE 1

TABLE 5-24 SCHEMATIC INTERPRETATION DETAIL EXAMPLE 1

Zone	Item Name	Explanation
1A	Power Source and Wires	**CB2** is the circuit breaker for the **M2** motor circuit. This circuit continues on Sheet 3, Zone 1D (**3/1D**). The symbol to the right indicates that this is input.
		The **Earth Ground** symbol and **R2**, **S2**, and **T2** are wire names that supply power to **CB2**.
1B	Flag and Motor Started	The flag **2 BL** is the specification for the M2 motor circuit wiring. **MS2** is a motor starter for motor M2 and is connected at terminals **1**, **3**, and **5**. This circuit continues on Sheet 221, Zone 3D (**221/3E**).
2B	Surge Killer	**SK2M** is a surge/spark killer protecting M2.
1C	Thermal Overload Relay	**TH2** is a thermal overload relay for motor **M2** and has a setting range of 5 to 8 amps (**5~8A**). This circuit is continued on Sheet 231, Zone 2A (**231/2A**). Motor wires **U2, V2,** and **W2** are connected to TH2 at terminals **2**, **4**, and **6**.
1D	System Component, Flags, Wire Names	**MAIN PANEL** is the area of the MTC for this portion of the circuit, and is indicated by solid line box. Circuit items in the dashed line box are not in the MTC. The flag **EXTERNAL** indicates that wires **U2**, **V2**, and **W2** are external to the MTC. The wire with the **Earth Ground** symbol indicates the motor M2 is grounded inside the MTC.
1E	Motor Symbol	This is a three-phase motor symbol. The motor name **M2** is placed inside the symbol. Motor **M2** is the **NOZZLE COOLANT** motor and rated at 1.06 kW at 50Hz or 1.21 kW at 60 Hz, **1.06KW (50Hz) 1.21KW (60Hz)**.

5.8.3 Example 2

Figure 5-28 shows a portion of the SPINDLE HEAD drawing, Sheet 202, of Drawing No. TEC02-0101E200. This example shows Zones 1A through 2E.

Example 2 Detail

Table 5-25 provides an explanation of the symbols, device names and location techniques used in Example 1 (Figure 5-28).

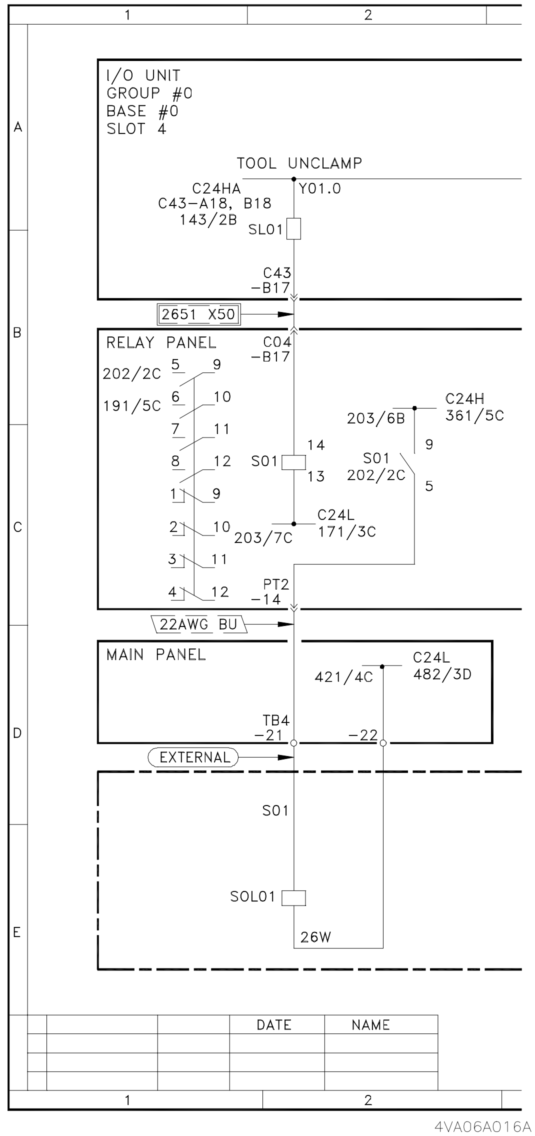


FIGURE 5-28 SCHEMATIC INTERPRETATION EXAMPLE 2

TABLE 5-25 SCHEMATIC INTERPRETATION DETAIL EXAMPLE 2

Zone	Item Name	Explanation
1A	System Component	I/O UNIT MT system area shown. GROUP#0 is the I/O rack number, BASE#0 is the I/O rack base No., and SLOT4 is the I/O module slot location. If one I/O rack is supplied its is GROUP#0, a second I/O rack would be GROUP#1.
	Signal Address and Meaning	**TOOL UNCLAMP** is the meaning of signal **SL01.** Below that **Y01.0** is the signal's PMC address.
	Source Connector	**C24HA** is the wire number at connector C43, pins A18 and B18, (**C43-A18, B18**) on the I/O module. Locator **143/2B** directs you to Sheet 143, Zones 2 and B for continuation of the circuit. SL01 is the wire number at connector C43, pin B17 (**C43-B17**).
1B and 1C	Relay Contact Detail	The flag **2651 x50** is the wire specification between con-nectors **C43** and **C04. C04** is a connector on the Relay Panel using pin **B17**. **RELAY PANEL** is the MTC area for this part of the circuit. The relay switch detail, Zones 1B and 1C shows wiring for normal switch positions, open or closed, pin numbers (**5** and **9**, **6** and **10**, etc.) and the location, **202/2C** and **191/ 5C,** of circuits using this relay.
2C	Relay Circuit	**S01** is the relay number and **13** and **14** are the relay coil pin numbers. Pin 14 is wired to connector C04, pin B17 (**C04-B17**). **C24L** is wired at pin 13 and is continued to Sheet 203, Zone 7C and Sheet 171, Zone 3C. **C24H** is wired at relay pin **9** and with continuation of the circuit to Sheet 361, Zone 5C and Sheet 203, Zone 6B. **S01** is wired at relay pin **5** with continuation of the circuit directed to Sheet 202, Zone 2C. Wire S01 is carried to the Main Panel by connector PT2, pin 14 (**PT2-14**).
1D	System Component	The flag **22AWG BU** is the specification for wire **S01** from **PT2-14** to **TB4-21** and to solenoid **SOL01**. **MAIN PANEL** is the MTC area for this part of the circuit. **C24L** is connected at **TB4-22** with circuit continuation on Sheet 421, Zone 4C (**421/4C**) and Sheet 482, Zone 3D (**482/3D**). **TB4-21** is terminal block TB4, terminal 21. The flag **EXTERNAL** means that **S01** from **TB4-21** to solenoid **SOL01** is external to the MTC.
2E	Solenoid	**SOL01** is the Unclamp solenoid name, S01 is its wire number, and 26W is the wattage rating of SOL01.

5.8.4 Schematic Symbol Table

Figure 5-29 shows the common graphic symbols and meaning used in the V55 Controller Maintenance Drawings.

Make a copy of this page and place it in front of your schematics for reference.

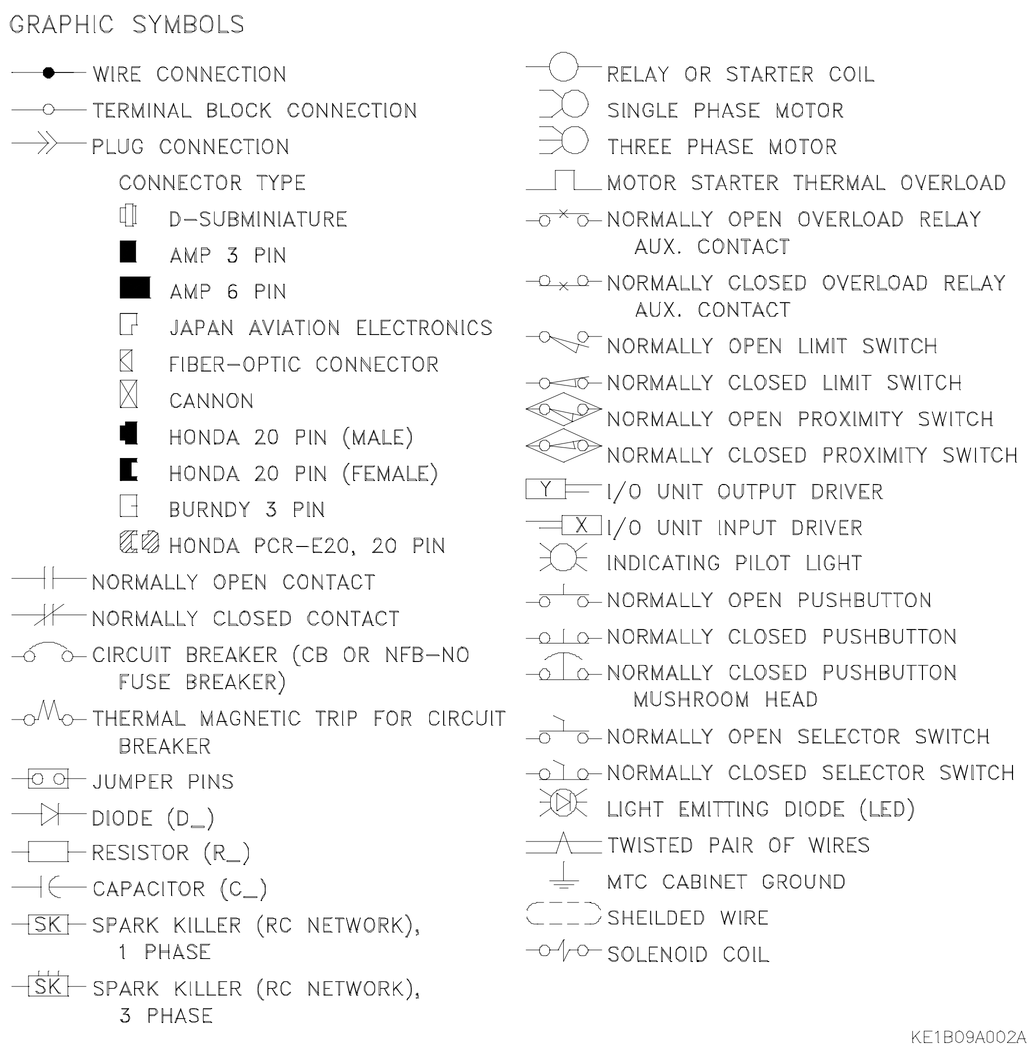


FIGURE 5-29 GRAPHIC SYMBOLS USED IN SCHEMATICS

NOTES:

SKETCHES:

NOTES:

SKETCHES:

Chapter 6 Spindle Head Unit

4V11A Type

#40 Taper, 14,000 or 20,000 RPM, and Through Spindle Coolant and Air

Makino V55 High-speed Vertical Machining Center

Chapter 6
Spindle Head Unit

Contents

NOTES:

SKETCHES:

6.1 Overview

This chapter contains information on maintaining the Makino V55 14,000 and 20,000 rpm, (11A Type) spindle heads, at peak operation.

Descriptions of the design, principle of operations, and procedures for maintenance and adjustment of the spindle's main assemblies, and peripheral components are provided.

The X and Z axes provide all spindle movement. The spindle assembly is contained within the ram casting. The ram casting travels vertically forming the Z axis and is mounted to the front of the saddle. The saddle is mounted on top of the column forming the X axis.

6.2 Spindle Design

Spindle rotation from 15 to 14,000 (or 200 to 20,000) rpm, programmable in 1 rpm increments, is provided by an integral AC servo motor consisting of a stator housed in the spindle cartridge and a rotor on the spindle shaft. Spindle rotation is monitored by a pulse coder ring/sensor assembly located at the rear of the spindle shaft. A Fanuc digital spindle drive system controls rotation, orientation, and rigid tapping.

The spindle is supported by two pre-loaded angular contact ball bearings at the nose and one single row roller bearing, at the top. This bearing arrangement provides maximum spindle rigidity and accuracy, by absorbing axial and radial cutting forces. The bearing pre-load is set at the factory.

- Spindle Nose Taper: 7/24 ISO #40 taper.

Tooling is securely retained in the spindle taper by the draw bar assembly, housed inside the spindle. The draw bar assembly consists of the draw bar, disc (Belleville) springs, and the collet finger assembly.

- Tool Clamping Force: 1980kg (4366lb)

The draw bar is a "positive mechanical" clamping mechanism and is "normally" clamped. Tooling is released when the spindle is unclamped, by hydraulically advancing the draw bar assembly.

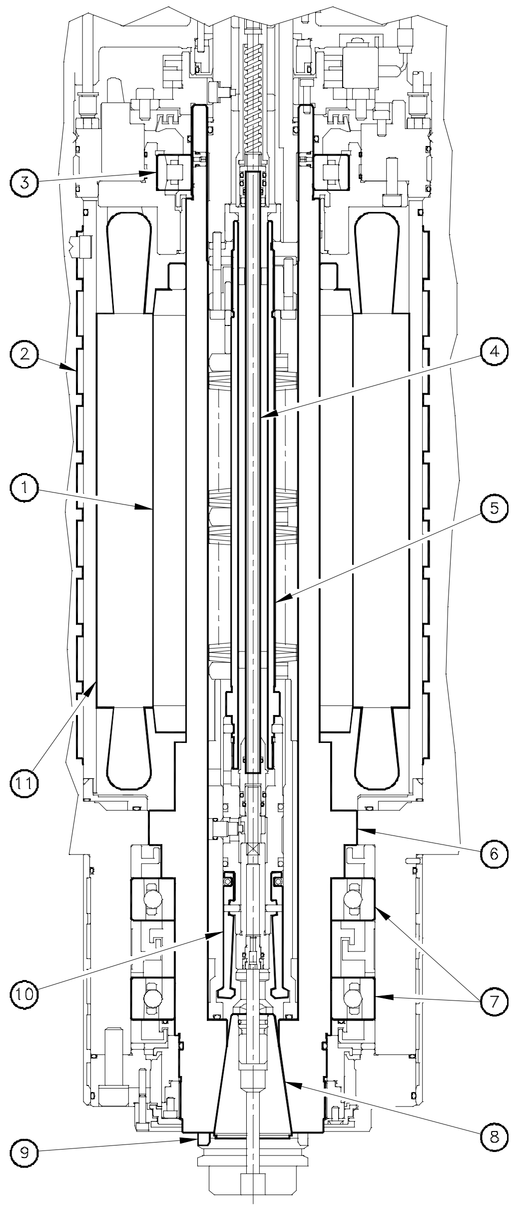
The spindle assembly is cooled and lubricated by Makino Spindle Lubricant which is pumped through the assembly by three pumps used for different cooling/lubricating functions. A compressor mounted pump supplies cooled and filtered oil from the oil controller through the unclamp cylinder housing into the area between the draw bar and spindle shaft I.D.

This lubricant cools the motor rotor and also passes through orifices in the spindle shaft for bearing lubrication. This lubricant is recirculated through the spindle, by a pump mounted on the back of the column, to maintain a constant temperature of the spindle assembly. The motor stator is cooled by lubricant pumped through a cooling jacket surrounding the stator.

Another pump, mounted on the back of the column, returns excess lubricant to the tank for processing by the oil controller unit. Cycling of the different pumps is controlled by oil controller or PMC parameter settings.

Through Spindle Coolant (TSC) is provided and accomplished by feeding coolant through a rotary coupling located at the top of the spindle assembly. Coolant is fed through a series of coolant tubes housed inside the draw bar. Numerous seals are used to contain the coolant and prevent contamination of the spindle lubrication system. A rubber seal is used to seal the joint between the tool holder retention knob and sealing rod.

- This seal and an O-ring located between the inner sleeve and sealing rod must be inspected frequently and replaced if damaged.



Legend

[1]	Motor Rotor	[7]	Angular Contact Bearing
[2]	Cooling Jacket	[8]	Spindle Taper
[3]	Cylindrical Roller Bearing	[9]	Drive Key
[4]	Thru Spindle Coolant Tube	[10]	Collet Finger Assembly
[5]	Draw Tube Assembly	[11]	Motor Stator
[6]	Spindle		

FIGURE 6-1 MAIN SPINDLE COMPONENTS

6.3 Specifications

Spindle specifications are presented in Table 6-1. Additional detail on tooling balance, related tooling information, and force and moment calculations follows.

TABLE 6-1 SPINDLE SPECIFICATIONS

Item	Specification Metric (Inch U.s.)	
Spindle Motor	Integral Rotor/Stator	
Cooling	Spindle Core Cooling	
Horsepower (25% ED/Continuous)	22 / 18.5 kW	(29.5 / 24.1 hp)
Maximum Horsepower at (rpm) †	5,000 rpm	
Constant Torque Range †	15 - 1,500 rpm	
Spindle Nose (Taper)	#40 Taper	
Spindle Tool Clamp Force	1980 kg	(4,366 lb)
Spindle Speed (1 RPM Increments)	15 - 14,000 rpm [200 to 20,0000 rpm - option]	
Spindle ID / OD	90 / 140 mm	
Bearings (Front)	(2) Angular Contact	
Bearings (Rear)	Single Row Cylindrical	
Through Spindle Air	Optional	
Through Spindle Air Pressure	0.5 MPa @ 0.6 m^3/min.	(70 psi @ 21.2 cfm)
Temperature Control	Temperature Controlled Cooling Oil	
Seals	Vacuum Created by Spindle Core Cooling Air Seals	
Maximum Radial (side) load or forces	45.45 kg	(100 lb)
Maximum Spindle Moment	10,000 kg·mm	(866.14 lb·in.)
† For more on spindle torque and power characteristics, see section 6.3.1.		

6.3.1 Spindle Power and Torque

Spindle Side Load

CAUTION

High-speed spindle bearings are susceptible to high radial thrust (force) and side load (moment). Exceeding the allowable force and moment limits of the spindle will; reduce tool life and part finish and cause premature bearing failure.

See section 6.4 for more detail on tooling balance, concentricity, overhang and force and moment calculations.

Figure 6-2 shows the 14,000 and 20,000 rpm spindle power and torque characteristics in relation to speed (rpm). The solid lines show the motor's continuous rating and the dashed lines show the motor's 15 minute duty rating.

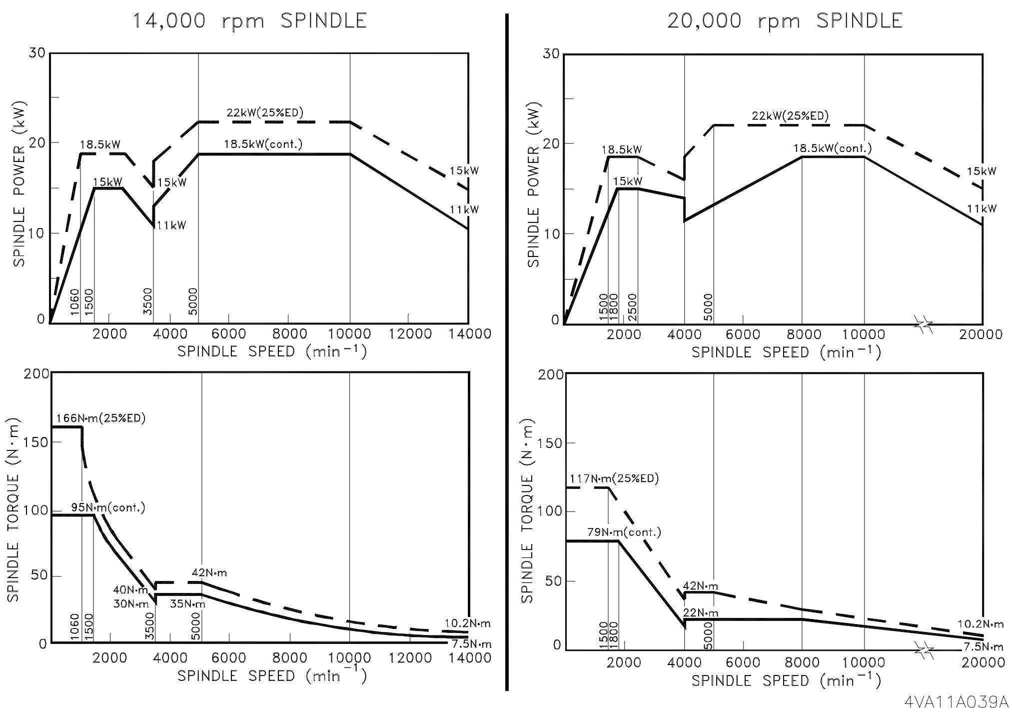


FIGURE 6-2 SPINDLE POWER AND TORQUE CHARACTERISTICS

EXAMPLE: The 14,000 rpm graph (continuous rating) shows spindle power climbing and maximum torque, from the minimum rpm up to the base speed of each motor winding. The base speed of the low speed winding is 1500 rpm and the high speed winding is 5000 rpm. From 5000 to 10,000 rpm, the high speed winding is active and power remains constant, but torque drops off. From 10,000 to 14,000 rpm both power and torque drop off. This indicates the need to program cutting conditions to use the spindle's power, rather than its torque. High-speed machining whether in steel or graphite, should require low load conditions and therefore benefit from high power rather than high torque characteristics.

6.3.2 Spindle Motor Output Specifications

Motor specifications are provided in Table 6-2 and 6-3.

TABLE 6-2 14,000 RPM SPINDLE MOTOR SPECIFICATION

Type	A06B-1233-B421 #xxxx				
Model No.	B112L-18.5/14000				
Power Factor	69%				
Motor Input	139 – 230V				
Amp. Input	200V 50/60Hz 3-Phase				
Ambient Temp.	0 - 40° C (32 - 104° F)				
Poles	4				
Standard	IEC#$-1/A2 1998				
Insulation Class	H				
Output Rating	Winding	Rating	RPM	kW	Amps (max.)
	Low – S1	Continuous	1500 ~ 2500	15	85
			2500 ~ 3500	11	
	Low – S2	30 Minute	1500 ~2500	18.5	100
			2500 ~ 3500	15	
	Low – S3	25% ED	1500 ~ 1800	18.5	133
	High – S1	Continuous	8000 ~ 10000	18.5	111
			10000 ~ 14000	11	
	High – S2	15 minute	5000 ~ 10000	22	123
			10000 ~ 14000	15	

TABLE 6-3 20,000 RPM SPINDLE MOTOR SPECIFICATION

<table>
<tr><td>Type</td><td colspan="5">A06B-1233-B421 #xxxx</td></tr>
<tr><td>Model No.</td><td colspan="5">B112L-18.5/20000</td></tr>
<tr><td>Power Factor</td><td colspan="5">69%</td></tr>
<tr><td>Motor Input</td><td colspan="5">139 – 230V</td></tr>
<tr><td>Amp. Input</td><td colspan="5">200V 50/60Hz 3-Phase</td></tr>
<tr><td>Ambient Temp.</td><td colspan="5">0 - 40° C (32 - 104° F)</td></tr>
<tr><td>Poles</td><td colspan="5">4</td></tr>
<tr><td>Standard</td><td colspan="5">IEC#$-1/A2 1998</td></tr>
<tr><td>Insulation Class</td><td colspan="5">H</td></tr>
<tr><td rowspan="10">Output Rating</td><td>Winding</td><td>Rating</td><td>RPM</td><td>kW</td><td>Amps (max.)</td></tr>
<tr><td rowspan="2">Low – S1</td><td rowspan="2">Continuous</td><td>1800 ~ 2500</td><td>15</td><td rowspan="2">82</td></tr>
<tr><td>2500 ~ 4000</td><td>11</td></tr>
<tr><td rowspan="2">Low – S2</td><td rowspan="2">30 Minute</td><td>1800 ~2500</td><td>18.5</td><td rowspan="2">96</td></tr>
<tr><td>2500 ~ 4000</td><td>15</td></tr>
<tr><td>Low – S3</td><td>25% ED</td><td>1500 ~ 1800</td><td>18.5</td><td>120</td></tr>
<tr><td rowspan="2">High – S1</td><td rowspan="2">Continuous</td><td>8000 ~ 10000</td><td>18.5</td><td rowspan="2">102</td></tr>
<tr><td>10000 ~ 20000</td><td>11</td></tr>
<tr><td rowspan="2">High – S2</td><td rowspan="2">15 minute</td><td>5000 ~ 10000</td><td>22</td><td rowspan="2">141</td></tr>
<tr><td>10000 ~ 20000</td><td>15</td></tr>
</table>

6.4 Application Considerations and Limitations

The V55 high-speed spindle has certain tolerances or limits, which must be considered to promote effective spindle operation and longevity.

6.4.1 Balance

Balancing ensures that an object's center of gravity is spinning equally around the rotational center of the body and is essential to effective HSM (high-speed machining).

Balanced tooling is essential for all machining operations regardless of spindle speed. Using balanced tools enhances surface finishes and reduces the potential for pre-mature spindle bearing failure. All tools used on the V55 MUST be balanced to within G2.5, or lower to prevent machining and machine problems, due to the forces from unbalanced tooling. An out of balance tool:

- Vibrates, causing chatter and exaggerated eccentricity, which decreases metal cutting capacity, resulting in reduced tool life and surface finish.
- Transfers excessive load to the spindle bearings, promoting premature or catastrophic failure. An unbalanced tool can generate over 50% of the recommended spindle side thrust.

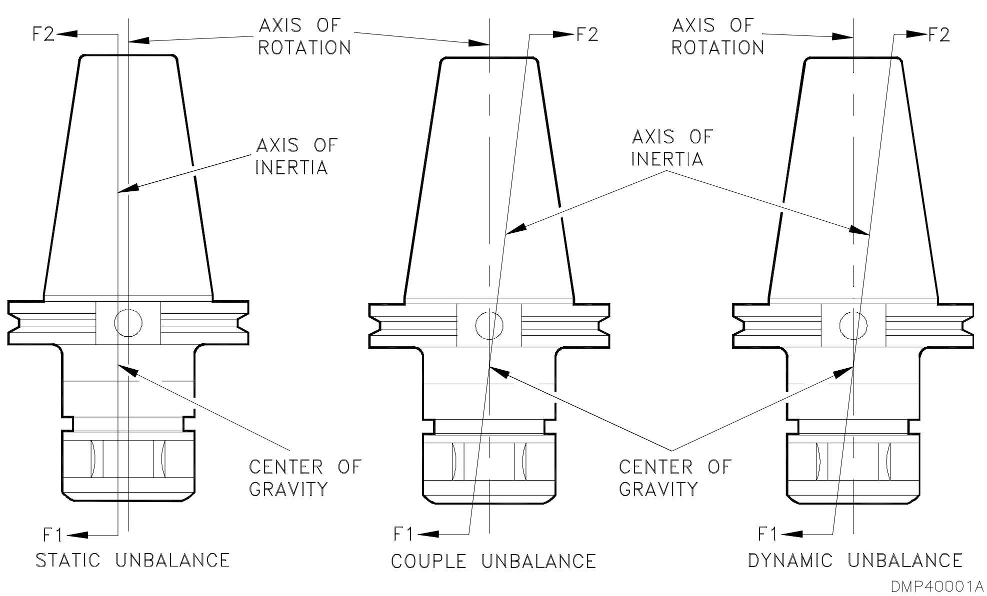


FIGURE 6-3 OUT-OF-BALANCE CONDITIONS

Balance the Entire Assembly

1. Although the cutting tool is not usually a problem in balancing, due to its small mass and typical symmetric shape makes balance almost inherent. To ensure cutter balance use high quality cutting tools with flutes, insert pockets, etc. equidistant from center. Do NOT use cutters with flats on the shank.
2. Balance the entire tool assembly to avoid “stacking” tolerances from individual components.

6.4.1.1 Specification and Calculation

Makino has established a balance specification of G2.5, or lower, for the V55 (the lower the specification the better the balance).

The balance specification establishes a range from which a “target balance”, for a tool at a given rpm, is calculated.

Tooling is then placed on a balancer and the out-of-balance amount or “unbalance” is measured in grams per millimeter (g·mm). Most balancers also indicate the area of unbalance. Material is then added or removed to bring the tool into the required balance specification.

If sending tools to a balancing service, use the formula in Table 6-4 to have them balanced to the G2.5 specification, for the maximum spindle rpm.

TABLE 6-4 TOOL BALANCE FORMULA

$g \cdot mm = \dfrac{M \times G \times 9.549}{RPM}$	G	= Balance Specification (G2.5)
	9.549	= Is a Constant of Acceleration
	RPM	= Max.Safe Spindle Speed
g·mm = Amount of Unbalance	M	= Tool Weight in Grams

To find the maximum safe RPM for a known unbalance amount, use the formula in Table 6-5.

TABLE 6-5 UNBALANCE TO RPM FORMULA

$\dfrac{1}{RPM} = \dfrac{g \cdot mm}{M \times G \times 9.549}$	G	= Balance Specification (G2.5)
	9.549	= Is a Constant of Acceleration
	RPM	= Max. Safe Spindle Speed
g·mm = Amount of Unbalance	M	= Tool Weight in Grams

6.4.1.2 Balanced Tool Holders

Tooling manufacturers can supply holders that are either balanced or balanceable. Balanced and balanceable holders cost more, but the benefit in surface quality alone will offset this cost in reduced time on the finishing bench.

When ordering holders:

- Order tooling with a G2.5 or lower grade specification at the machine’s maximum rpm.
- Ensure the holder will operate safely and successfully at the required rpm.

Tooling you currently own can be sent to a service for balancing. Depending on cost and delivery of balancing individual tools and the number of tools balanced per year, the purchase of a tool balancer machine may be justified.

Operation of a tool balancer machine is not difficult, but requires training and machinery to properly remove or add material to obtain balance.

6.4.2 Concentricity

Concentricity is important in all machining applications, but it is imperative for effective HSM. It is particularly important when using tools with more than one cutting edge.

If the tool’s cutting edges do not swing through the same arc they are said to be eccentric or “runout” as shown in Figure 6-4.

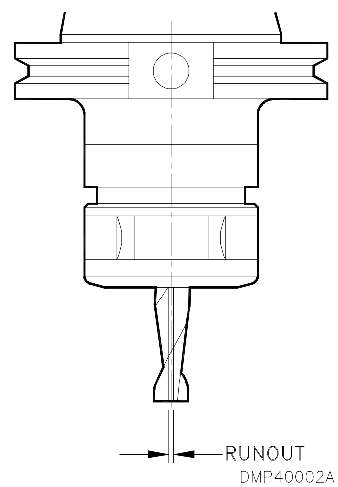


FIGURE 6-4 RUNOUT OR ECCENTRICITY

On an eccentric tool, the outside edge wears more quickly resulting in a wider “wear land” which shortens the edge’s life. A wider “wear land” on one edge places unequal side pressure on the tool, which adversely affects balance, deflection, radial load, and surface finish.

Sources of runout are extensions, bushings, and adapters. Do not use extensions, especially at higher spindle speeds. Use bushings and adapters only when absolutely necessary.

Other sources of runout are dirty tool shanks, unmatched tapers (holder to spindle taper), and a bell-mouth condition in the holder or spindle taper.

To protect against runout:

- Do not use extensions and adapters.
- Keep tool holder and spindle tapers clean.
- Purchase high-quality tooling.
- Inspect tooling on a comparator.

6.4.3 Rigidity

Tool rigidity significantly impacts performance and results of any machining operation. Using the shortest and most rigid tool possible helps ensure the highest repeatability, precision, and reliability.

The quality of any milling operation is affected greatly by the length of the tool. An extended tool flexes, affecting the final tolerance, finish, and tool life.

Tool holders are essentially a cantilevered beam. Its deflection under load is proportional to the cube of its length.

$(D \propto l^3)$

This should underscore the importance of minimizing overhang or length to diameter (L/D) ratio.

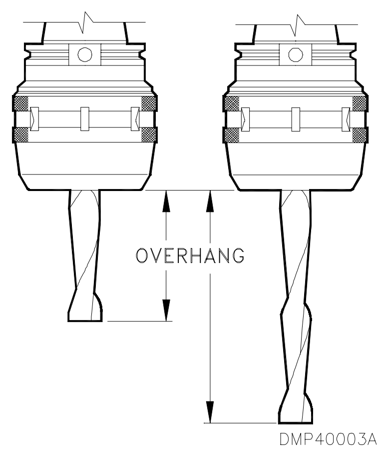


FIGURE 6-5 TOOL OVERHANG

- Reducing tool length by 50 percent makes the tool eight times stronger or more rigid.
- The greater the holder’s rigidity the greater its dampening capacity, dynamic stillness, and integrity.

6.4.4 Gage Length

When selecting a balanced tool holder consider the length of the holder from the gage line. Gage line is the point on a tool holder (and spindle) where the diameter of the taper measures 2.75” on a #50 taper and 1.75” on a #40 taper.

Select a tool holder with the shortest possible gage length.

Gage length is the distance from gage line to the snout face on a tool holder or the end of the tool as shown in Figure 6-6. Gage length is also called tool length.

A tool holder with a short gage length is more rigid than one with a longer gage length.

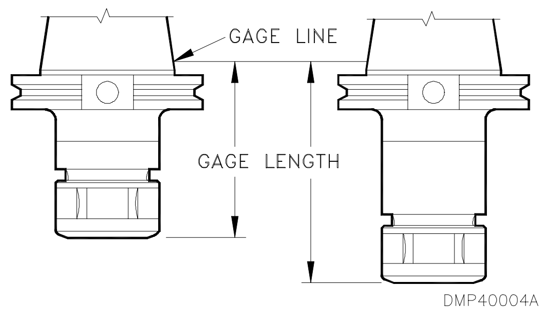


FIGURE 6-6 GAGE LENGTH

If a longer overhang is required, use a tool holder with a longer gage length and a short cutting tool. The holder provides more rigidity than the cutting tool.

6.4.5 Radial Load - Force and Moment

Operating equipment within its limitations reduces machining problems, maintenance, and down time while prolonging machine life.

V55 high-speed spindles have two load limits – force and moment – which must not be exceeded.

- To promote maximum spindle bearing life and cutting performance. A Macro program to calculate force and moment is provided in Table 6-8.

6.4.5.1 Force

Force or radial thrust – 45.45kg (100lb)

Force is the load transmitted to the bearings by the combined effects of; tool balance and concentricity, spindle speed (rpm), depths of cut (radial and axial), feedrate, and chip load. The force formulae (metric and inch) are provided in Table 6-6.

TABLE 6-6 FORCE FORMULAS (METRIC AND INCH)

To find force, in metric, use the formula below: Force = 25(kg) · *Rd*(mm) · A*d*(mm) · *F*(mm/min) · *Sz*(mm/tooth)	
To find force, in inch, use the formula below: Force = 55(lb) · *Rd*(in) · A*d*(in) · *F*(in/min) · *Sz*(in/tooth)	
Where:	
Rd = Radial Depth of Cut	*F* = Feedrate
Ad = Axial Depth of Cut	*Sz* = Chip load

6.4.5.2 Moment

Moment – 10,00 kg·mm (866.14lb·in.)

Moment is the combined effects of force and tool length. The allowable moment on a V55 spindle is less than 10,000kg·mm (866.14lb·in.). The metric and inch moment formula are presented in Table 6-7.

TABLE 6-7 MOMENT FORMULAS (METRIC AND INCH)

To find Moment in Metric use the formula below: Moment = *F*(kg) · *L*(mm)	
To find Moment in Inch use the formula below: Moment = *F*(lb) · *L*(in)	
Where:	
F = Force (from previous calculation)	*L* = Tool Length (from Gage line)

6.4.5.3 Force and Moment Macro

Table 6-8 provides a Macro program, developed by Makino, to simplify force and moment calculations. This program is to be entered into the control and used by Operators during set-up. The program automates the calculations for both metric or inch.

The Operator need only key in the variables, as they apply to current operations:

Force is calculated in kilograms or pounds. If the result exceeds the 45.45kg or 100lb limit, an alarm – “FORCE TOO GREAT, SEE #101”, is issued.

Tool moment is calculated in kg mm or lb in. If the result exceeds the 10,000kg·mm or 866.14lb·in. limit, an alarm – “MOMENT TOO GREAT, SEE #100” is issued.

- If an alarm is issued, adjust your cutting conditions to change one or more of the variables supplied to the Macro.

TABLE 6-8 FORCE AND MOMENT MACRO PROGRAM

Macro Call Format	
Format: G65 P9123 R___ A___ F___ C___ S___ H___;	
R = Radial depth of cut	C = Chip load (feed per tooth / revolution)
A = Axial depth of cut	S = Spindle speed (rpm)
F = Number of flutes	H = H code (Tool length offset number)
Macro program O9123 (TOOL MOMENT CALCULATION);	
IF [#18 EQ #0] GOTO1;	Check R validity
IF [#1 EQ #0] GOTO1;	Check A validity
IF [#9 EQ #0] GOTO1;	Check F validity
IF [#3 EQ #0] GOTO1;	Check C validity
IF [#19 EQ #0] GOTO1;.	Check S validity
IF [#11 EQ #0] GOTO1;	Check H validity
#10 = 25;	Variable #10 is set to 25kg
#12 = 360000;	Metric test denominator (constant)
#13 = 10000 (MAX. METRIC MOMENT);	Maximum metric tool moment (kg·mm)
#15 = 45.45 (MAX. FORCE IN KILOGRAMS);	Maximum side force in kg
IF [#4006 EQ 21] GOTO2;	Check CNC for unit of measure, inch/metric
#10 = 55;	Variable #10 is set to 55lb.
#12 = 0.8649;	Inch test denominator (constant)

TABLE 6-8 FORCE AND MOMENT MACRO PROGRAM (CONTINUED)

#13 = 866.14 (MAX. INCH MOMENT);	Maximum inch tool moment (lb in.)
#15 = 100 (MAX. FORCE IN POUNDS);	Maximum side force in lb
N2 #14 = #9 * #3 * #19;	Calculate feedrate per minute
#101 = [#10 * #18 * #1 * #14 * #3] / #12;	Calculate force
#100 = #101 * #[2000 + #11];	Calculate tool moment
IF [#101 LT #15] GOTO3;	Compare calculated force to max. allowed
#3000 = 0 (FORCE TOO GREAT, SEE #101);	Alarm message
N3 IF [#100 LT #13] GOTO4;	Compare calculated moment to max. allowed
#3000 = 0 (MOMENT TOO GREAT, SEE #100);	…Alarm message
N1 #3000 = 0 (TOOL MOMENT COMMAND ERROR);	…Alarm message
N4 M99;	End of Macro

In Case of Alarm

If an alarm is issued by the Macro program for either force or tool moment, change the cutting conditions (i.e. feedrate, spindle rpm, tool length, etc.) to reduce the value of one or more variables then rerun the program.

6.5 Spindle Clamp/Unclamp

Figure 6-7 shows the main components of the spindle clamp/unclamp mechanism.

Tooling is clamped in the spindle taper by the gripping action of the collet finger assembly on the tool holder retention knob.

A clamping force of 1980kg (4366lb) is generated by a set of coned disc (Belleville) springs mounted on the draw bar. This design provides a “positive mechanical” clamping mechanism and provides a spindle which is “normally” clamped.

Spindle unclamp is accomplished hydraulically with the unclamp cylinder, which provides a thrust of 2800kg (6174lb).

“Spindle Tool Knock-out” occurs during the unclamp stroke. Since the tool holder retention knob is seated against the sealing rod when a tool is clamped in the spindle, draw bar advancement during unclamp pushes the tool from the spindle taper.

- Tool knock-out: 1.5 to 1.8mm (0.06 to 0.07")
  - The tool knock-out distance includes approximately 1.0mm (0.04") of sealing rod spring compression.

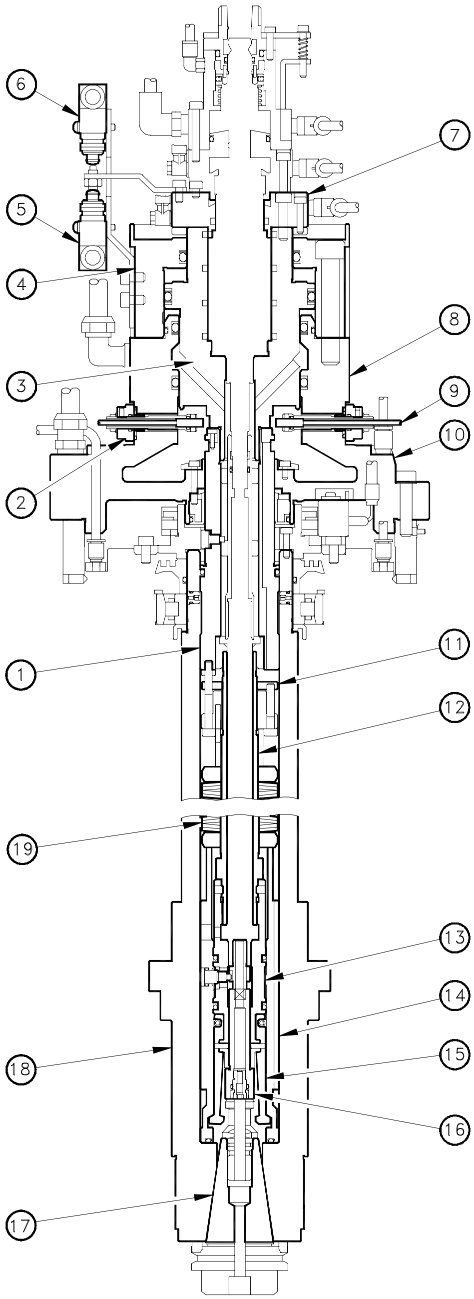


FIGURE 6-7 CLAMP UNCLAMP COMPONENTS

Legend

[1]	Sleeve
[2]	LS601 Proximity Switch
[3]	Piston
[4]	Cylinder
[5]	LS01 Limit Switch
[6]	LS00 Limit Switch
[7]	Cylinder Retainer
[8]	Cylinder Case
[9]	LS602 Proximity Switch
[10]	Spindle Head
[11]	Lock Nut
[12]	Draw Bar - Upper Section
[13]	Draw Bar - Lower Section
[14]	Collet Fingers Sleeve
[15]	Collet Fingers
[16]	Sealing Rod
[17]	Spindle Taper
[18]	Spindle
[19]	Disk Springs

6.5.1 Clamp/Unclamp Mechanism

During unclamp – (Figure 6-8) the unclamp solenoid SOL01 (**Y01.0**) is energized porting hydraulic oil to the top of the unclamp cylinder [1] and piston [2] moves (downward) advancing the entire draw bar assembly. As the draw bar assembly advances, the disk springs [9] compress and the collet fingers [4] move into a recess in sleeve [3]. The collet fingers [4] open, releasing the retention knob [8].

Spindle unclamp is confirmed by LS01 (**X00.1**)

Tool Knock-out occurs at the end of stroke pushing the tool [6] out of the spindle taper [7]. Tool knock-out = 1.5 to 1.8mm (0.06 to 0.07")

During clamp– the unclamp solenoid SOL01 **(Y01.0)** is de-energized, exhausting hydraulic oil from the top of the cylinder [1]. Piston [2] retracts, by the force of the disk springs [9] and the draw bar and collet fingers [4] return to their normal clamped state.

During retract, the collet fingers [4] move out of the sleeve recess [3] and grip tool holder retention knob [8] which seats against the sealing rod [5].

Spindle clamp is confirmed by LS00 (**X00.0**)

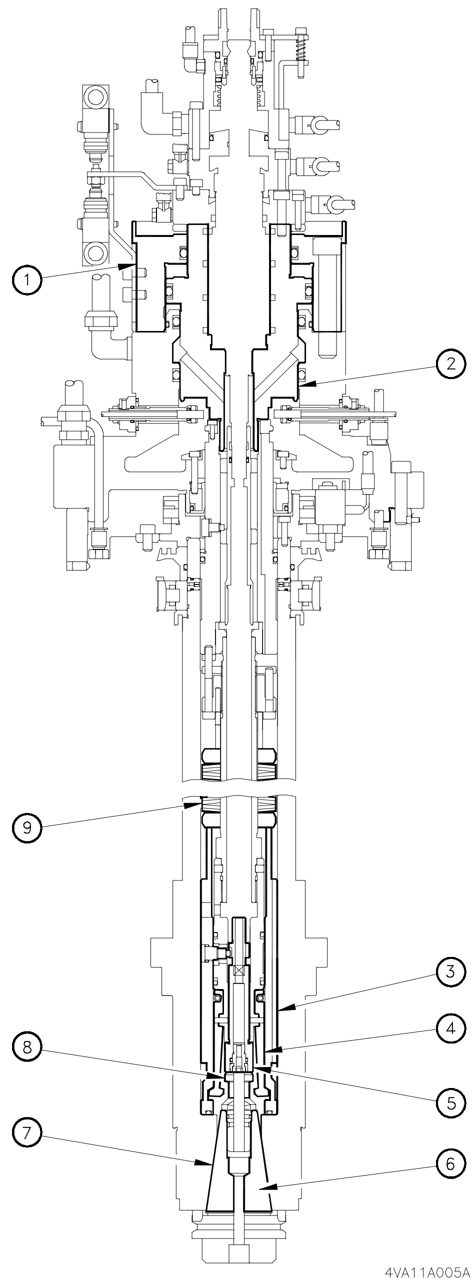


FIGURE 6-8 CLAMP/UNCLAMP MECHANISM

During ATC operations, taper cleaning air SOL09 (**Y01.0**) is energized during unclamp. This air blast purges contaminates from the spindle taper and tool holder shank. During spindle clamp operations SOL09 (**Y01.0**) is de-energized.

6.5.2 Draw Bar Assembly

CAUTION

For Reference Only

The draw bar assembly is an integral part of the high-speed spindle assembly. Removal and installation should be performed only by Makino technicians. Maintaining critical alignments and balance, during assembly, is extremely important. Makino requests that our customers do NOT attempt to repair this assembly.

The draw bar assembly is integral to the spindle assembly and provides a positive mechanical clamping mechanism to hold tooling securely into the spindle taper.

The draw bar assembly consists of:

[1] Disk Springs
[2] Nut
[3] Inner Sleeve
[4] Tool Confirm Switches
[5] Tool Confirm Collar
[6] Outer Sleeve
[7] Lock Nut
[8] Spindle
[9] Draw Bar - Upper Section
[10] Draw Bar - Lower Section
[11] Collet Finger Assembly
[12] Collet Finger Sleeve

Troubleshooting:

Draw bar assembly related problems rare and generally limited to:

- A broken or cracked disk spring.
- A bent pin in the collet finger assembly. See section 6.5.4, for more detail.

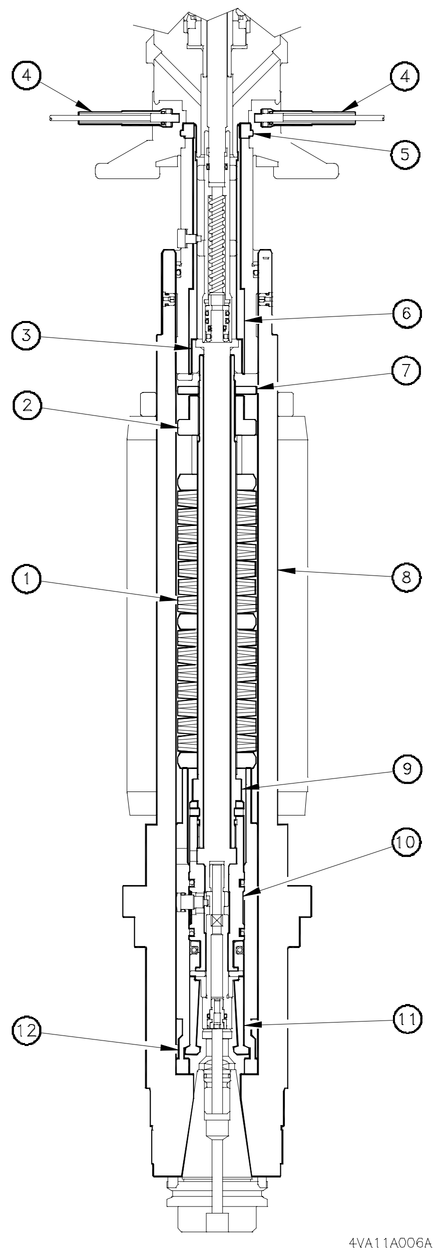


FIGURE 6-9 DRAW BAR ASSEMBLY

6.5.3 Drawbar Retention Force

The tool holder is clamped in the spindle by the gripping action of the collet fingers on the tool holder retention knob.

A clamp force of 1980kg (4366lb) is generated by a set of disc (Belleville) springs mounted on the drawbar. This design provides a positive mechanical clamping mechanism. The normal state of the spindle is clamped.

Makino recommends checking the retention force periodically to ensure that the clamping mechanism is providing the proper force. Loss of retention force is the result of weakened or cracked disc springs.

Retention force is measured with a calibrated gage called a “Drawbar Dynamometer” (Figure 6-10). These gages vary widely in price and quality. An acceptable source for this gage is listed below, contact them for price and delivery:

Address:

Command Corporation International
11501 Eagle St. NW
Minneapolis, Minnesota USA 55448
Telephone: (800) 328-2197
Voice Mail: (612) 755-2229
Fax: (612) 755-1116

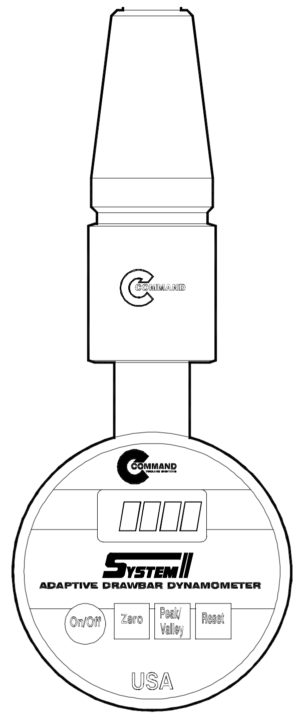


FIGURE 6-10 DRAWBAR DYNAMOMETER

6.5.4 Collet Finger Assembly

For Reference Only

CAUTION

The collet finger assembly is an integral part of this high-speed spindle assembly. Removal and installation should be performed only by Makino technicians. Maintaining critical alignments and balance, during assembly, is extremely important. Makino requests that our customers do NOT attempt to repair this assembly.

Figure 6-11 shows the collet finger assembly, in the clamp and unclamp state.

This assembly consists of:

[1] Collet Sleeve
[2] Spring
[3] Pins
[4] Collet Fingers

During unclamp, the draw bar advances, moving the collet finger assembly down.

The collet fingers [4], which hang on the pins [3] enter the recess [8] in the collet sleeve [1] and are forced open by the spring [2], releasing retention knob [5].

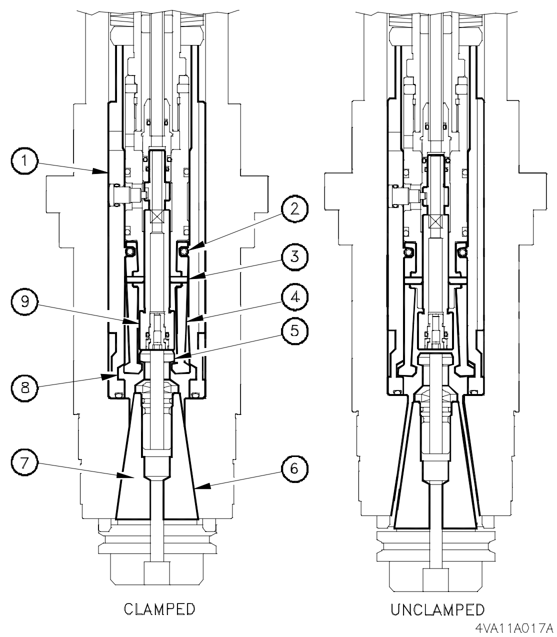


FIGURE 6-11 COLLET FINGER ASSEMBLY

As the draw bar completes the unclamp stroke, sealing rod [9] pushes the tool holder [7] from the spindle taper [6].

- Tool knock-out is provided to overcome the seating action, which can occur between tapers during machining.

6.5.5 Hydraulic Equipment

Spindle clamp/unclamp is accomplished by system hydraulic pressure (set to 7 MPa (1017 psi)), the unclamp assembly, and solenoid valve SOL01 (clamp).

The unclamp cylinder (Figure 6-12) is an integral part of the spindle assembly and consists of the cylinder retainer [1], cylinder case [3], cylinder [2], and the piston [4].

During unclamp, the cylinder generates 2800kg (6174lb) force; during clamp 1980kg (4366lb) is generated.

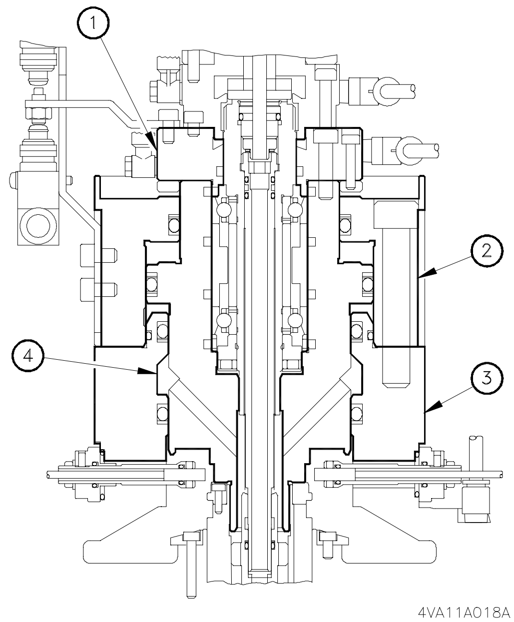


FIGURE 6-12 UNCLAMP CYLINDER

6.5.5.1 Location

The unclamp cylinder is located above and in-line with the spindle assembly. A rotary coupling and associated parts for through spindle coolant, is mounted to the cylinder retainer (Figure 6-12).

Solenoid SOL01 is located in the upper left corner of the Hydraulic and Air Unit cabinet, on the right side of the machine (Figure 6-13).

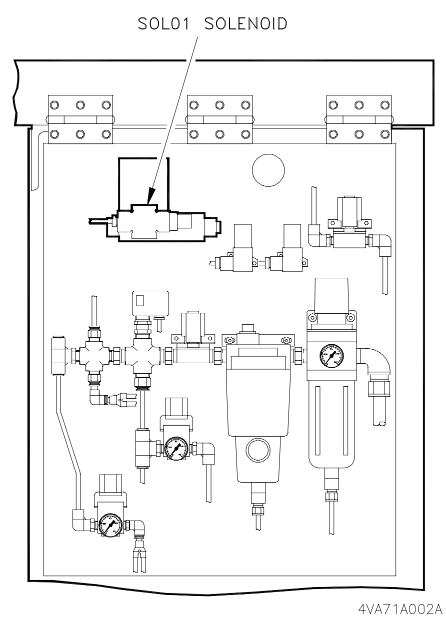


FIGURE 6-13 SOL01 LOCATION

6.5.5.2 Unclamp Cylinder Removal and Replacement

CAUTION

Unclamp Cylinder Removal

The unclamp cylinder is an integral part of this high-speed spindle assembly. Removal and installation should be performed by Makino, in a clean room environment. Maintaining critical alignments and balance during assembly is extremely important. Makino requests that our customers do NOT attempt to repair this assembly.

6.5.5.3 Operation

Spindle clamp/unclamp is initiated by energizing and de-energizing solenoid SOL01. When SOL01 is energized the spindle unclamps. When SOL01 is de-energized, the spindle clamps. Table 6-9 shows the necessary status of the solenoid and output signal for spindle clamp/unclamp operations.

TABLE 6-9 CLAMP/UNCLAMP SOLENOID CONDITIONS

Spindle State	SOL01
Clamp	Y01.0 = 0
Unclamp	Y01.0 = 1

6.5.5.4 Operating Speed and Adjustment

The operating speed of the unclamp piston is set at the factory and requires no further adjustment.

6.5.5.5 Unclamp Cylinder Air Purging

Air in the unclamp cylinder hydraulic system will cause slower tool changes. If the tool unclamp action (during automatic tool change) takes longer than 0.3 second, use the following procedure to remove air from the unclamp cylinder hydraulic system.

This procedure requires a special test hose (Part No. Z467B7004000) available from Makino):

1. Using the [TOOL UNCLAMP] button
   A. Remove any tooling from the spindle
   B. Clamp the spindle (without a tool).
2. Reference the Z axis.
3. Power down the machine and perform Lockout/Tagout”.

4. Remove the upper spindle cover, see section 6.10 (pg 6-80).
5. Remove the caps on the unclamp cylinder pressure (P) and relief (T) hydraulic lines (Figure 6-14 (pg. 6-24)).
6. Connect Test Hose between lines (P) and (T).
7. Power up the machine.
8. Press [TOOL UNCLAMP] to unclamp the spindle.
9. Wait 10 seconds, then press [TOOL UNCLAMP] to clamp the spindle.
10. Repeat STEPS 8 and 9, three times.
11. Power down the machine.
12. Disconnect the Test Hose and reconnect the caps on lines (P) and (T).
13. Check unclamp speed.
    A. Alternately clamp and unclamp the spindle.
    B. Confirm that spindle unclamp takes less than 0.3 second.

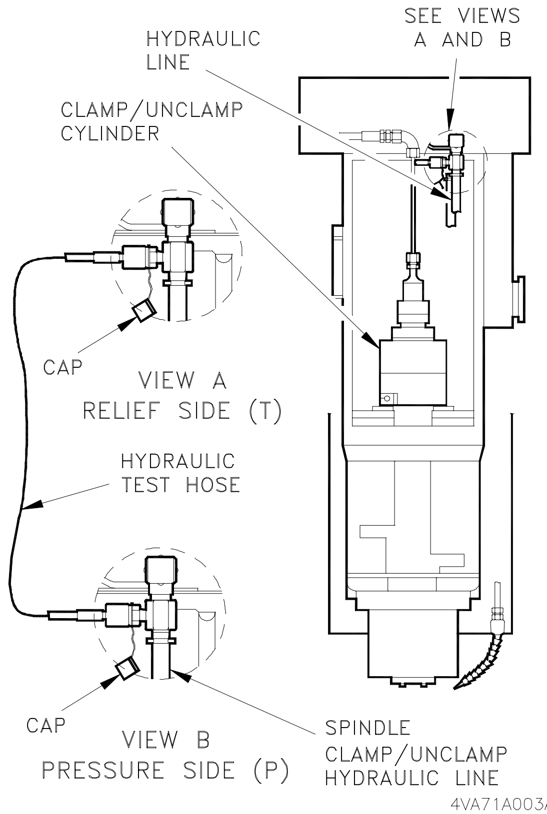


FIGURE 6-14 TEST HOSE CONNECTION

- If the spindle does not unclamp within the limit, reconnect the Test Hose and repeat STEPS 8 through 13.
- If the unclamp action is within the limits, proceed to STEP 14.
- If the unclamp action continues to exceed 0.3 seconds, contact your Makino service group.

14. Check for hydraulic leaks.
15. Install the upper spindle cover.

NOTES:

SKETCHES:

6.5.6 Clamp/Unclamp Limit Switches (LS00/LS01)

Spindle clamp/unclamp operation is confirmed by two plunger type limit switches. LS00 detects spindle clamp and LS01 detects spindle unclamp.

Software INTERLOCKS halt operation, if the clamp/unclamp limit switch conditions are improper or if the clamp state is lost during machining.

6.5.6.1 Location

Limit switches LS00 and LS01 are located behind the upper spindle cover. To access LS00 and LS01 remove the upper spindle cover, see section 6.10 (pg 6-80).

Figure 6-15 shows the mounting arrangement of LS00 and LS01. When viewed from the front of the spindle; LS00 (spindle clamp) is the top switch and LS01 (spindle unclamp) is the bottom switch

6.5.6.2 Operation

The clamp/unclamp limit switches [3] are mounted to a bracket [6] attached to the unclamp cylinder housing [5].

A trip dog [1] for each switch is mounted to a bracket [2] attached to the upper draw bar bearing retainer [4].

Spindle clamp and unclamp conditions are indicated and confirmed by the On/Off conditions of LS00 (**X00.1**) and LS01 (**X00.0**), as shown in Table 6-10.

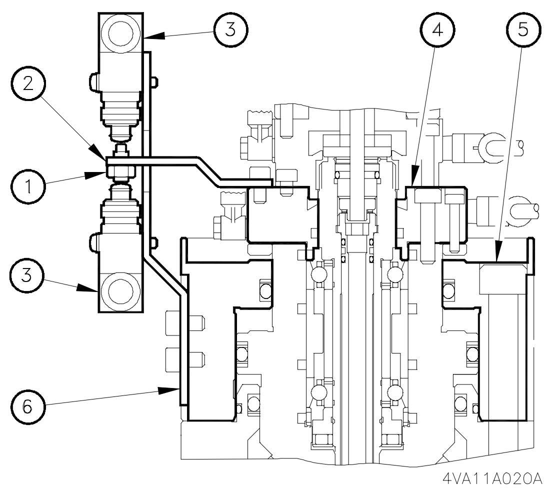


FIGURE 6-15 LIMIT SWITCH ARRANGEMENT

TABLE 6-10 CLAMP/UNCLAMP LIMIT SWITCH CONDITIONS

Spindle State	LS00	LS01
Clamp	X00.0= 1	X00.1= 0
Unclamp	X00.0= 0	X00.1= 1

6.5.6.3 LS00 and LS01 Adjustment

The following procedures are for use in adjusting limit switches LS00 (spindle clamp) and LS01 (spindle unclamp). A switch's trip position is set by adjusting its trip dog set screw.

The objective is to set both switches, slightly beyond the position, where they change state from low (0) to high (1).

To adjust the clamp/unclamp limit switches, proceed as follows:

1. Determine which limit switch needs adjustment. Use Testing Switch Operation (pg 6-28).
2. Adjust the limit switch, requiring adjustment. Use Adjusting LS00 (pg 6-29) or Adjusting LS01 (pg 6-30).
3. If a malfunctioning switch cannot be adjusted by these procedures, replace the switch as described in section 6.5.6.4

Testing Switch Operation

Use this procedure to determine if LS00 or LS01 require adjustment

1. Display the Custom - DIAGNOSE screen (Figure 6-16).
   A. Press the [CUSTOM] function key. (If required, press [PO] to display the [MS] softkey.)
   B. Press [MS], to display [DIAGNOSE].
   C. Press the [DIAGNOSE].

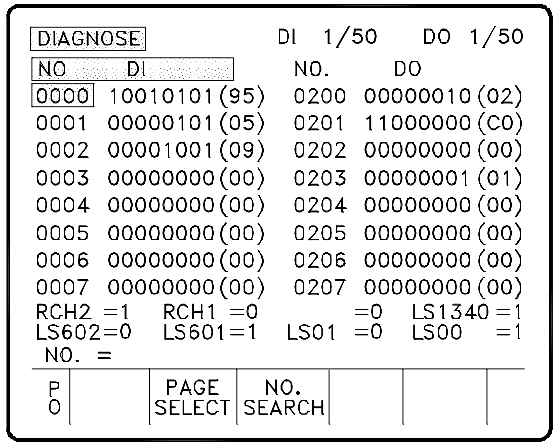


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FIGURE 6-16 CUSTOM DIAGNOSE SCREEN

2. Use [NO. SEARCH], to display Diagnostic No. 00.
   - The status of LS00 **(X00.0)** and LS01 **(X00.1)** is displayed at the bottom of the screen.
3. Manually load a tool into the spindle.
   A. Select a Manual Mode (Jog, Handle, or Rapid).
   B. Press the [TOOL UNCLAMP] button, to unclamp the spindle.
   C. Insert the tool.
   D. Press [TOOL UNCLAMP], to clamp the spindle.
4. Check the status of LS00 and LS01. With spindle clamped and tool present, inputs should be: LS00 **(X00.0) = 1** and LS01 **(X00.1) = 0**.
5. Use [TOOL UNCLAMP] and manually remove the tool in the spindle.
6. Check the status LS00 and LS01. With the spindle unclamped and no tool, inputs should be: LS00 **(X00.0) = 0** and LS01 **(X00.1) = 1**.

- If the status of any input differs from that given in STEPS 4 or 5, that limit switch requires adjustment.

Adjusting LS00

1. Display the Custom - DIAGNOSE screen (Figure 6-17).
   A. Press the [CUSTOM] function key. (If required, press [PO] to display the [MS] softkey.)
   B. Press [MS], to display [DIAGNOSE].
   C. Press the [DIAGNOSE].
2. Use [NO. SEARCH], to display Diagnostic No. 00.
   - The status of LS00 **(X00.0)** and LS01 **(X00.1)** is displayed at the bottom of the screen.

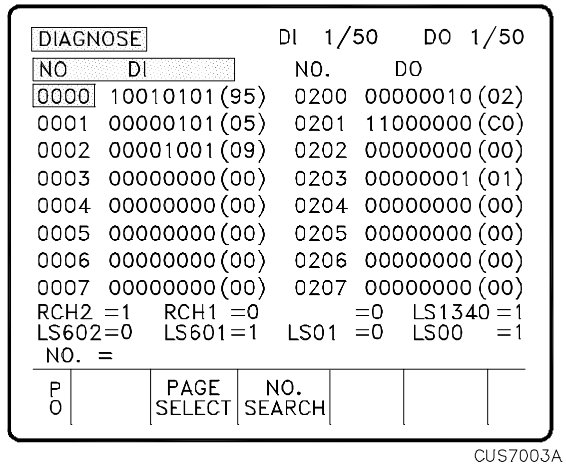

FIGURE 6-17 CUSTOM DIAGNOSE SCREEN

3. Remove the upper spindle cover, section 6.10
4. Using the [TOOL UNCLAMP] button, manually load a tool into the spindle.
5. Loosen the (M6) lock nut [1].
6. Turn adjusting screw [2] CCW, until the input for LS00 [3] goes low (**LS00 = 0**).
7. Turn adjusting screw [2] CW, until the input for LS00 [3] just goes high (**LS00 = 1**), then turn 1.5mm (0.060") further, and tighten lock nut [1].
8. Use [TOOL UNCLAMP] to manually remove the tool from the spindle.
9. Check the input status of LS00 and LS01 and readjust, if necessary.
   - With spindle unclamped, inputs should be: **LS00 = 0** – **LS01 = 1**
   - With spindle clamped, inputs should be: **LS00 = 1** – **LS01 = 0**
10. Replace the upper spindle cover.

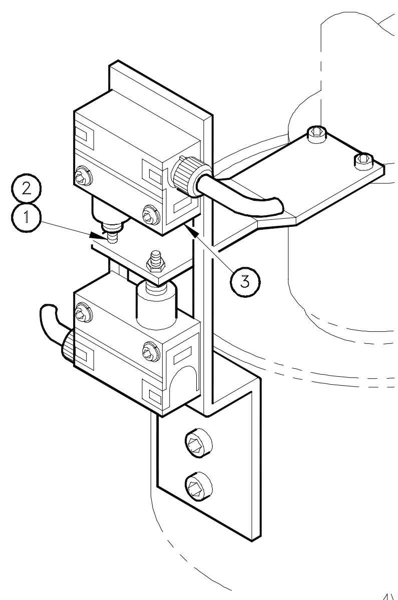

FIGURE 6-18 LS00 ADJUSTMENT

Adjusting LS01

1. Display the Custom - DIAGNOSE screen (Figure 6-19).
   A. Press the [CUSTOM] function key. (If required, press [PO] to display the [MS] softkey.)
   B. Press [MS], to display [DIAGNOSE].
   C. Press the [DIAGNOSE].

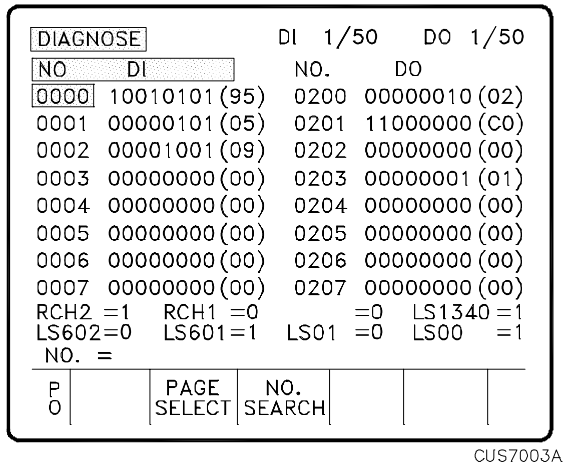

FIGURE 6-19 CUSTOM DIAGNOSE SCREEN

2. Use [NO. SEARCH], to display Diagnostic No. 00.
   - The current status of LS00 **(X00.0)** and LS01 **(X00.1)** is displayed at the bottom of the screen.
3. Remove the upper spindle cover, section 6.10 (pg 6-80).
4. Use the [TOOL UNCLAMP] button and manually remove tooling from the spindle.
5. Loosen the (M6) lock nut [1].
6. Turn adjusting screw [2] CCW, until the input for LS01 goes low (**LS01 = 0**).
7. Turn adjusting screw [2] CW, until the input for LS01 just goes high (**LS01 = 1**), then turn 1.5mm (0.060") further, and tighten lock nut [1].
8. Use [TOOL UNCLAMP] to manually load a tool into the spindle.
9. Check the input status of LS00 and LS01 and readjust, if necessary.
   - With spindle unclamped, inputs should be: **LS00 = 0 and LS01 = 1**
   - With spindle clamped, inputs should be: **LS00 = 1 and LS01 = 0**
10. Replace the upper spindle cover.

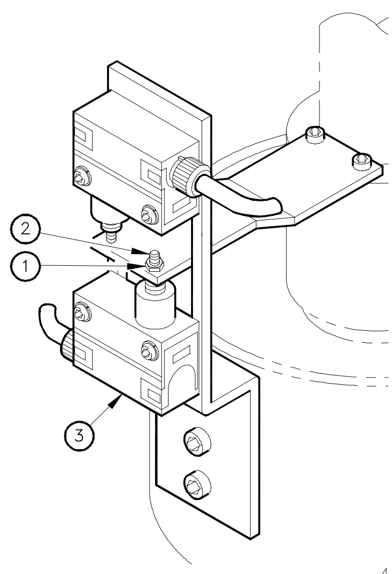

FIGURE 6-20 LS01 ADJUSTMENT

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6.5.6.4 Removal and Replacement - LS00 or LS01

This procedure is for the removal and replacement of LS00 or LS01.

1. Remove the upper spindle cover, section 6.10.
2. Reference the Z axis.
3. Power down the machine and perform Lockout/Tagout procedures.
4. Remove the spindle head terminal box cover, to access the limit switch wire connections. Four (M5x8) cross-head screws.
5. Disconnect the wires, at terminal TB2, for the switch being replaced.
6. Go fishing.
   A. Connect a “fish tape”, or length of string, as a fishing line, to the disconnected wires.
   B. Pull the wires through to the front of the spindle head and disconnect the fishing line from the old wires. Do not remove the fishing line at this time.
7. Remove the defective limit switch [4]. Two (M4 x 22) screws [1] and two (M4) lock washers [2].
8. Install new switch on mounting bracket [3].
9. Connect the fishing line to the new switch wires and pull the wires back into the spindle head terminal box.
10. Connect the switch wires at terminal TB2.
11. Replace the terminal box cover.
12. Start the machine and adjust the limit switch(es), as described in Adjusting LS00 (pg 6-29) or Adjusting LS01 (pg 6-30).
13. Replace the upper spindle cover.

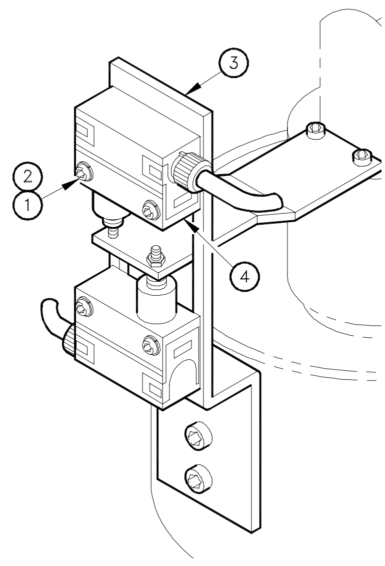


FIGURE 6-21 LS00/LS01 REMOVAL AND REPLACEMENT

6.5.7 Tool Confirmation Limit Switches (LS601/LS602)

The design of the through-spindle-coolant system and draw bar mechanism requires that tooling be properly clamped and seated in the taper before the spindle is started. Two proximity switches are provided to confirm proper tool to spindle status.

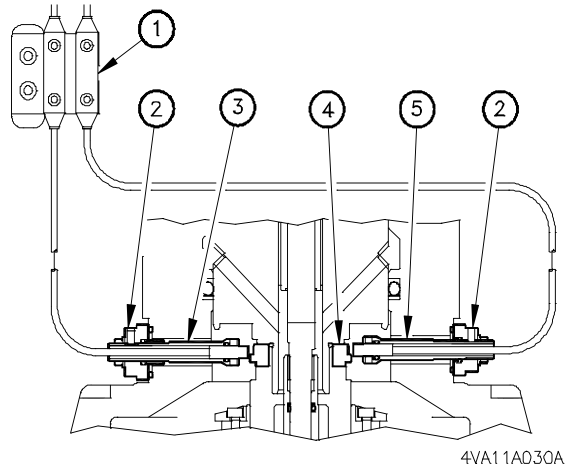


FIGURE 6-22 TOOL CONFIRMATION MECHANISM

The mechanism consists of two amplified proximity switches [2] and [4], two bracket assemblies [1] with three O-ring seals (each), and a trip dog [3] (called fitting collar, in the Parts Manual).

The prox switch sensor is attached to a threaded holder by a set screw. The sensor gap is adjusted by a lock nut and secured by a set screw.

6.5.7.1 Location

The tool confirmation limit switches are mounted in bracket assemblies attached to the side of the unclamp cylinder, behind the lower spindle cover. LS601 is on the left and LS602 is on the right, when viewed from the front of the spindle.

6.5.7.2 Operation

LS601 **(X00.2)** confirms a tool in the spindle and LS602 **(X00.3)** confirms an empty, unclamped, or improperly clamped spindle. Switch status may be determined by; viewing the Custom - DIAGNOSE screen, or the color of its amplifier LED, as shown in Table 6-11.

TABLE 6-11 LS601 AND LS602 SIGNAL STATUS

Condition	LED Color		Input Status	
	LS601	LS602	LS601	LS602
Tool In Spindle, Clamped	GREEN (ON)	RED (OFF)	X00.2 = 1	X00.3 = 0
Spindle Unclamped	RED (OFF)	RED (OFF)	X00.2 = 0	X00.3 = 0
Spindle Empty, Clamped	GREEN (ON)	GREEN (ON)	X00.2 = 1	X00.3 = 1

The operating condition for LS601 **(X00.2)** and LS602 **(X00.3)** are shown in Figure 6-23 and described below.

View A – (spindle clamped with tool present) The draw bar assembly is retracted (upward) but the full stroke of the draw bar is restricted by the tool clamped in the spindle.

- In this condition, LS601 is activated **(X00.2 = 1)** and LS602 is deactivated (X002.3 = 0).

View B – (spindle unclamp, no tool) The draw bar assembly is advanced (down).

- In this condition, LS601 is deactivated **(X00.2 = 0)** and LS602 is deactivated **(X002.3 = 0)**.

View C – (spindle clamp, no tool) The draw bar assembly is in the full up position.

- In this condition, LS601 is activated **(X00.2 = 1)** and LS602 is activated **(X002.3 = 1)**.

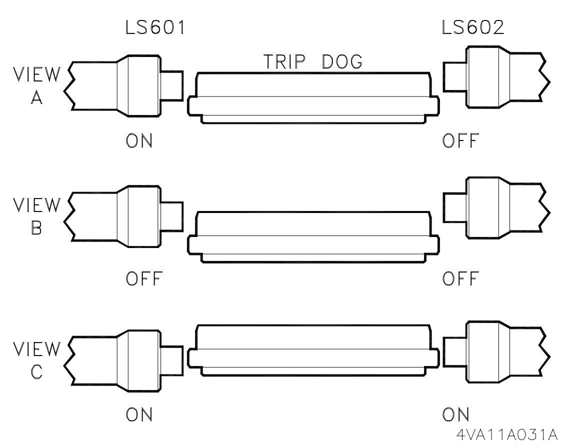


FIGURE 6-23 TOOL CONFIRM SENSOR-TO-DOG RELATIONSHIP

6.5.7.3 LS601 and LS602 Adjustment

Use the following procedures for adjusting proximity switches LS601 (tool in spindle) and LS602 (spindle empty).

The trip position is set by adjusting both the gap between the switch face and trip dog and the vertical position where the switch state changes from low (0) to high (1).

- The objective is to set both switches, slightly beyond the position, where they change state from low (0) to high (1).

To adjust the tool confirm proximity switches, proceed as follows:

1. Determine which prox switch needs adjustment. Use Testing Switch Operation (pg 6-35)
2. Adjust the prox switch, requiring adjustment. Use Adjusting LS601 (pg 6-36) or Adjusting LS602 (pg 6-38).
3. If a malfunctioning switch can not be adjusted by these procedure, replace the switch, as described in section 6.5.7.4 (pg 6-40).

Testing Switch Operation

Before making adjustments to LS601 and LS602, use this procedure to determine which switch requires adjustment.

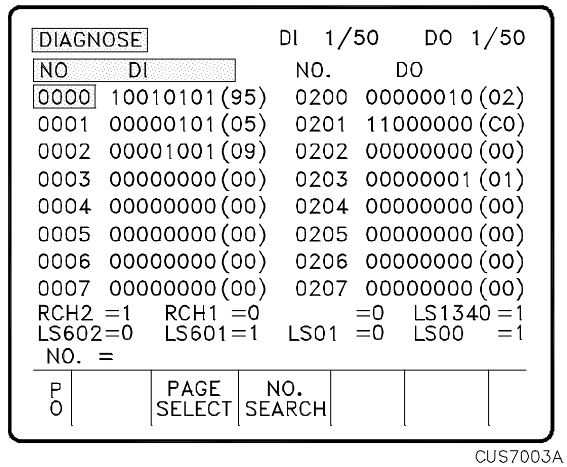


FIGURE 6-24 CUSTOM DIAGNOSE SCREEN

1. Display the Custom - DIAGNOSE screen (Figure 6-19).
   A. Press the [CUSTOM] function key. (If required, press [PO] to display the [MS] softkey.)
   B. Press [MS], to display [DIAGNOSE].
   C. Press the [DIAGNOSE].
2. Use [NO. SEARCH], to display Diagnostic No. 00.
   - The status of LS00 **(X00.2)** and LS01 **(X00.3)** is displayed at the bottom of the screen.
3. Manually load a tool into the spindle.
   A. Select a MANUAL mode (Jog, Handle, or Rapid).
   B. Press the [TOOL UNCLAMP] button, to unclamp the spindle.
   C. Insert the tool.
   D. Press [TOOL UNCLAMP], to clamp the spindle.
4. Check limit switch status with a tool clamped in the spindle. Status should be: LS601 **(X00.2) = 1** and LS602 **(X00.3) = 0**.
5. Use the [TOOL UNCLAMP] button and manually remove the tool from the spindle.
6. Check limit switch status with the spindle unclamped. Status should be: LS601 **(X00.2) = 0** and LS602 **(X00.3) = 0**.
7. Press [TOOL UNCLAMP] to clamp the spindle without a tool present.
8. Check limit switch status with the spindle clamped and not tool. Status should be: LS601 **(X00.2) = 1** and LS602 **(X00.3) = 1**.

- If the status of either input is incorrect, for the conditions setup in Steps 4, 6 and 8, that prox switch requires adjustment.

Adjusting LS601

When setting LS601, its On/Off status is determined by viewing the amplifier LED or the input status on the Custom - DIAGNOSE screen. This procedure uses the amplifier LED.

- The objective of this setting procedure is to first set the switch gap then set the trip position.

1. To access the prox switches:
   A. Remove the upper spindle cover, section 6.10.
   B. Remove the spindle nose O-ring retainer and O-ring, four (M4x5) cross-head screws.
   C. Remove the lower spindle cover, six (M5x10) cross-head screws.
2. Using the [TOOL UNCLAMP] button, manually load a tool into the spindle.
3. Set the gap between the switch sensor and trip dog (Figure 6-25):
   A. Loosen the two (M4x12) mounting screws [1].
   B. Slide switch bracket [2] down (as far as it can go).
   C. Tighten mounting screws [1].
   D. Loosen set screw [3] and switch holder adjusting nut [4].
   E. Push the switch (toward spindle), until it touches the dog.

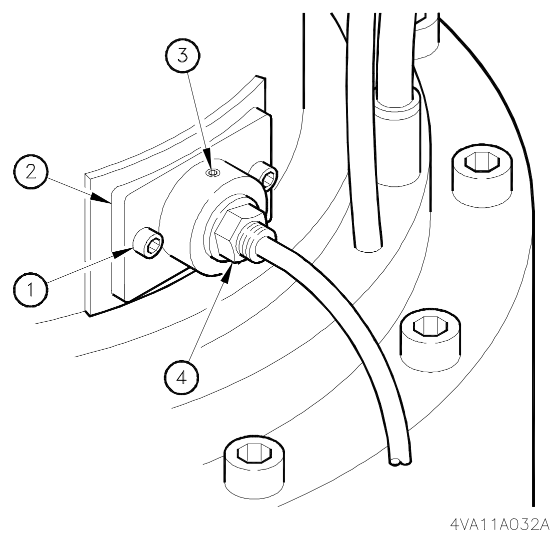


FIGURE 6-25 LS601 ADJUSTMENT

   F. Turn adjusting nut [4] CW to touch the mounting bracket, then turn one full turn (CW), further.
   - This sets a 1.5mm (0.060") gap between the sensor and dog.
   G. While observing LS601's amplifier LED and pushing the switch holder "in", turn adjusting nut [4] CCW, until the LED changes from red to green. Then turn adjusting nut [4] CCW one more flat.
   H. Tighten the switch holder set screw [3].

4. Loosen screws [1], to allow bracket [2] to move, but keep it against the casting.
5. Slide bracket [2] “up” as far as it can go. LED should change from green to red. If not, the gap is set too close, repeat STEP 3.
6. Slide bracket “down” until LED changes from red to green, then slide it “down” another 1.5mm (0.060").
7. Tighten mounting screws [2].
8. Perform theTesting Switch Operation (pg 6-35), to confirm proper operation of both LS601 and LS602.
9. Replace spindle covers and associated parts removed in STEP 1.

Adjusting LS602

When setting LS602, its On/Off status can be viewed on its amplifier (LED) or the Custom - DIAGNOSE screen. This procedure uses the amplifier LED.

- The objective of this setting procedure is to first set the switch gap then set the trip position.

1. To access the prox switches:
   A. Remove the upper spindle cover, section 6.10.
   B. Remove the spindle nose O-ring retainer and O-ring, four (M4x5) cross-head screws.
   C. Remove the lower spindle cover, six (M5x10) cross-head screws.
2. Using the [TOOL UNCLAMP] button, manually load a tool into the spindle.
3. Set the gap between the switch sensor and trip dog (Figure 6-25):
   A. Loosen the two (M4x12) mounting screws [1].
   B. Slide switch bracket [2] “up” as far as it can go.
   C. Tighten the mounting screws [1].
   D. Loosen set screw [3] and adjusting nut [4].
   E. Push the switch “in” until it touches the dog.
   F. Turn adjusting nut [4] (CW) until it touches the mounting bracket then one full turn (CW) more.
   - This sets a 1.5mm (0.060") gap between the sensor and dog.
   G. While observing the LED and pushing “in” on the switch holder, turn the adjusting nut [4] (CCW) until the LED changes from red to green then turn the nut (CCW) one more flat.
   H. Tighten the switch holder set screw [3].

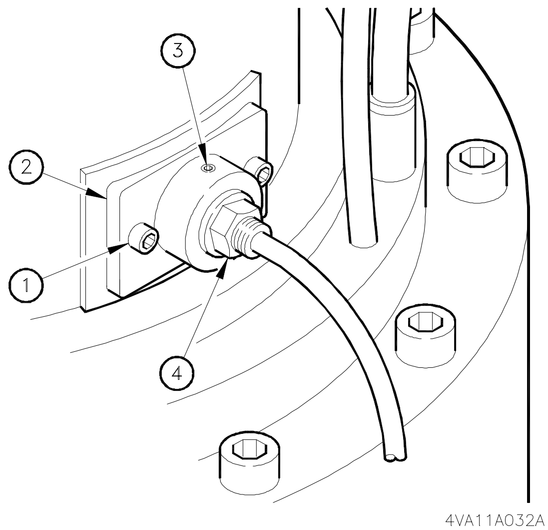


FIGURE 6-26 LS602 ADJUSTMENT

4. Loosen the mounting screws [1] to allow bracket [2] to move but hold it against the casting.
5. Slide the bracket “down” as far as it can go.
   - LS602 LED should change from green to red. If not, the gap is set too close, repeat STEP 3.
6. Slide the bracket “up” until LED changes from red to green then slide it “up” an additional 1.5mm (0.060").
7. Tighten mounting screws [1]
8. Perform the Testing Switch Operation (pg 6-35) procedure.
9. Replace spindle covers and associated parts removed in STEP 1.

6.5.7.4 Removal and Replacement - LS601 or LS602

The procedure for removing and replacing LS601 and LS602 is the same. After replacing either switch, follow the appropriate adjustment procedure; Adjusting LS601 (pg 6-36) or Adjusting LS602 (pg 6-38).

CAUTION

IMPORTANT

When replacing a switch, it is important that the switch sensor does not extend too far out of its holder and that the overall dimension from the back face of the switch bracket to the sensor face is maintained. This dimension is controlled by the switch holder adjusting nut. Extending the sensor face too far from the back face of the switch bracket could cause interference between the sensor and dog.

1. To access the prox switches:
   A. Remove the upper spindle cover, section 6.10.
   B. Remove the spindle nose O-ring retainer and O-ring, four (M4x5) cross-head screws.
   C. Remove the spindle lower cover, six (M5x10) cross-head screws.
2. Reference the Z axis.
3. Power down the machine and perform Lockout/Tagout procedures.
4. Remove the spindle head terminal box cover, to access the prox switch wire connections. Four (M5x10) cross-head screws.
5. Disconnect the wires, at TB2, for the switch being replaced.
6. Go fishing.
   A. Connect a “fish tape”, or length of string, to be used as a fishing line, to the disconnected wires.
   B. Pull the wires through to the front of the spindle head and disconnect the fishing line from the old wires. Do not remove the fishing line at this time.
7. Remove the prox switch amplifier from its mounting bracket.
8. Remove the two (M4x12) mounting screws and remove the switch bracket assembly from the spindle casting.
   - Do not loosen set screw [4] or loosen the switch holder adjusting nut [5].

9. Remove O-ring [3] (Figure 6-27).
10. Determine initial switch setting (Figure 6-28).
    A. Measure from the sensor face to the back face of the switch bracket, dimension **A**.
    B. Measure from the sensor face to the end of switch holder, dimension **B**. Dimension **B** should not exceed 6mm (0.236").

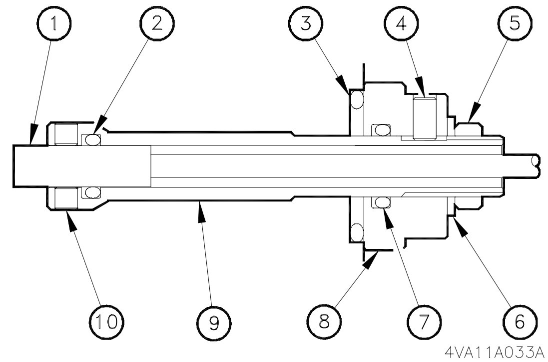


FIGURE 6-27 SWITCH BRACKET ASSEMBLY

11. Loosen the two (M4x12) set screws [10] and pull sensor [1] out of holder [9].
12. Remove O-ring [2] from inside the switch holder. Inspect the O-ring and replace, if there are any signs of damage. Use a good quality O-ring lubricant when replacing the O-ring.

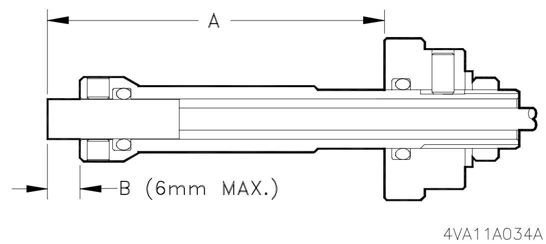


FIGURE 6-28 INITIAL SWITCH SET-

13. Install the new switch sensor [1] into its holder [9]. Be careful not to pinch or cut the O-ring [2].
14. Set the sensor face to the distances measured in STEP 9

More Detail

1. First set dimension B, then set dimension A.
2. It may be necessary to loosen set screw [4] and turn adjusting nut [5] to obtain dimension A. If so, tighten set screw [4] after setting A.

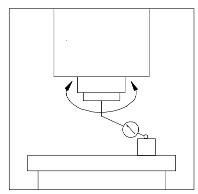
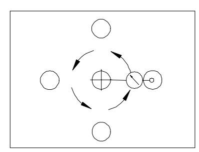
15. Place the switch bracket assembly and O-ring [3] into the spindle casting and install the two mounting screws.
16. Mount the switch amplifier on its mounting bracket.
17. Connect the fishing line to the new switch wires and pull the wiring back to the spindle head terminal box.
18. Connect the switch wires at TB2 and replace the terminal box cover.
19. Power up the machine and adjust the prox switch(es), as described in Adjusting LS601 (pg 6-36) or Adjusting LS602 (pg 6-38).
20. Replace spindle covers and associated parts removed in STEP 1.

6.6 Spindle-To-Table Squareness

Spindle-to-table squareness should be checked whenever the spindle head position has been disturbed. This includes; head moving due to a collision or removal for repair.

Table 6-12 shows the spindle-to-table squareness check in the machine runoff record. Refer to your machine's runoff record for the actual squareness reading at assembly.

TABLE 6-12 SPINDLE-TO-TABLE SQUARENESS CHECK

Inspection Item		Measuring Method	Illustration	Tolerance	Actual Reading
SQUARE-NESS BETWEEN SPINDLE CENTER-LINE AND THE TABLE TOP SURFACE	X AXIS	Place the X and Y axes at mid travel. Fix a test indicator in the spindle. Set the indicator to the table surface (via a parallel block) at 0 to 180° for X axis and 90 to 270° for Y axis by turning the spindle. The difference of readings in each direction is the measured value.		0.008/300mm (0.0003/11.8")	
	Y AXIS			0.008/300mm (0.0003/11.8")	

6.6.1 Checking Squareness

To check spindle-to-table squareness, use Table 6-13 and proceed as follows.

TABLE 6-13 SPINDLE-TO-TABLE SQUARENESS TOLERANCES

Axis	Metric	Inch
X	0.008mm in 300mm	0.0003” in 11.8”
Y	0.008mm in 300mm	0.0003” in 11.8”

1. Clean the table surface.
   A. Remove all workpieces, fixtures, vices, etc., from the table.
   B. Thoroughly clean the table surface using a safe solvent and lightly stone the table surface to remove any high spots.
   C. Wipe the surface clean, using a safe solvent.
2. Set-up a 0.002mm (0.00005") indicator, to check spindle-to-table squareness, as shown in Figure 6-29.
   A. Place a tramming bar or knuckle set, into a tool holder [2].
   B. Place the tool holder [2] in the spindle [1].
   C. Set the indicator [3] to swing a 150mm radius.

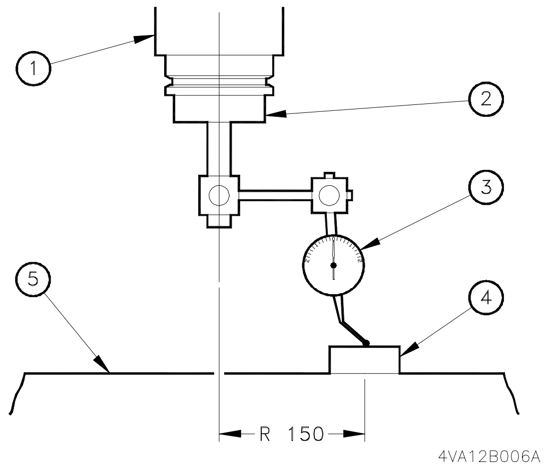


FIGURE 6-29 INDICATOR SETUP

3. Check spindle-to-table squareness in the X axis.
   A. Manually rotate the spindle so the indicator [3] is parallel to the table T-slots.
   B. Place a precision gage block [4] on the table, under the indicator.
   C. Using the MPG, move the Z axis to zero the indicator against the gage block.
   D. Confirm a repeatable indicator reading by sliding the gage block out from and back under the indicator stylus.
   E. Turn HANDLE mode Off, to prevent Z axis movement during measurement.
   F. Rotate the spindle 180 degrees and slide the gage block back under the indicator stylus, at the 180 degree position.
   G. Read the indicator deflection amount. This is the amount of deviation from square, in the X axis plane. See Table 6-13 for the X axis plane squareness tolerance.
4. Check spindle-to-table squareness in the Y axis.
   A. Manually rotate the spindle 90 degrees so the indicator [3] is perpendicular to the table T-slots and facing towards the operator.

B. Slide the gage block [4] back under the indicator stylus.

C. Using the MPG, move the Z axis to zero the indicator against the gage block.

D. Confirm a repeatable indicator reading by sliding the gage block out from and back under the indicator stylus.

E. Turn HANDLE mode Off, to prevent Z axis movement during measurement.

F. Rotate the spindle 180 degrees and slide the gage block back under the indicator stylus, at the 270 degree position.

G. Read the indicator deflection amount. This is the amount of deviation from square in the Y axis plane. See Table 6-13 for the Y axis plane squareness tolerance.

6.6.2 Correcting Squareness

Axes alignments, including spindle-to-table squareness, are inherent with the manufacturing and assembly process. All flatness, parallelism, and perpendicular alignments are controlled by precision machining and final hand scraping of the linear motion guide mounting surfaces.

An out-of-tolerance condition of spindle-to-table squareness is a strong indication that there has been a machine wreck and warrants further investigation. Depending on the severity of a machine wreck, damage could result to the spindle assembly and the Z or X axes linear motion guides.

Machine out-of-level may also affect spindle-to-table squareness. Level the machine as described in chapter 3. If this does not correct the spindle-to-table squareness, contact your Makino service group for assistance.

6.7 Spindle Drive System

The V55 spindle drive system consists of the following components:

- Integral spindle motor with built-in position coder
- Power Supply Module, Fanuc model - PSM-26 for the 14,000 rpm spindle (PSM-30 for the 20,000 rpm spindle)
- Spindle Amplifier Module, Fanuc model - SPM-30

Figure 6-30 shows a block diagram of the spindle drive system.

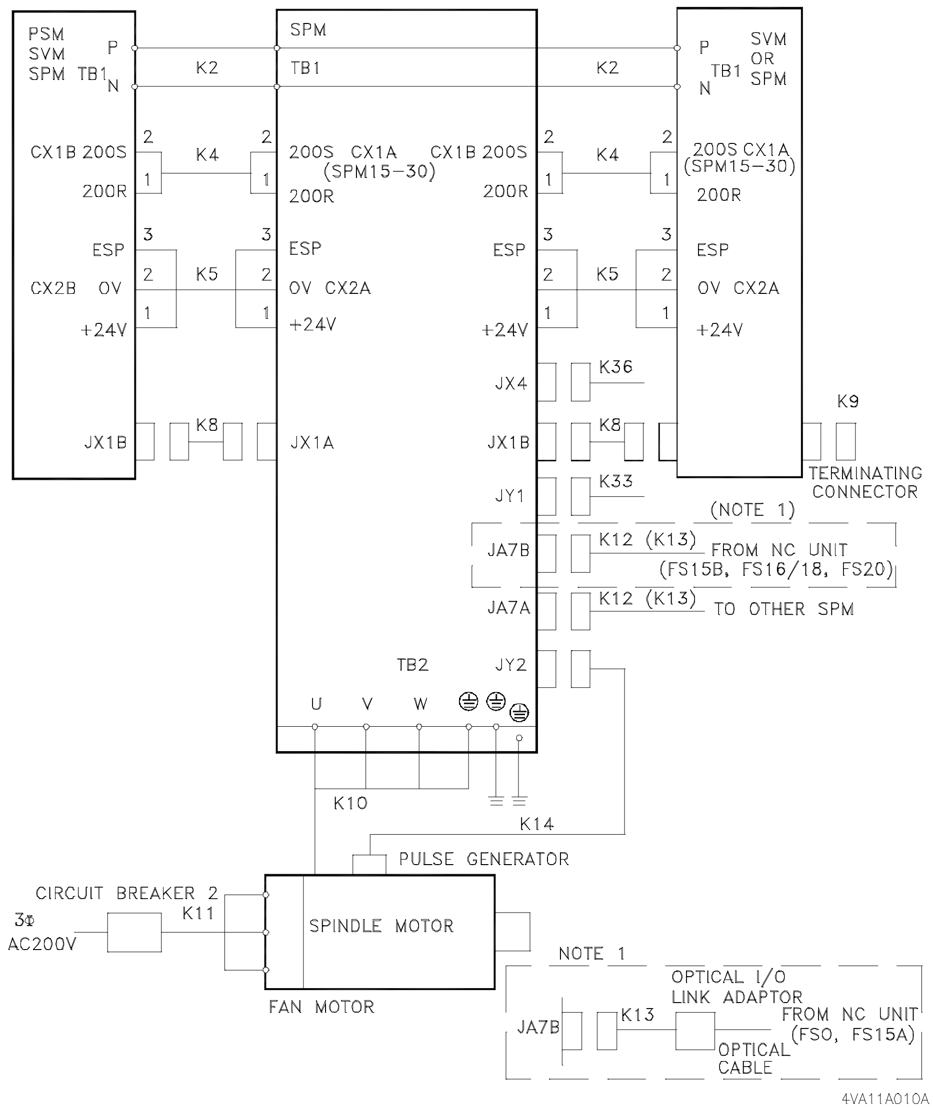


FIGURE 6-30 SPINDLE DRIVE SYSTEM BLOCK DIAGRAM

6.7.1 Integral Spindle Motor

The spindle drive motor is integral to the spindle assembly. The rotor is mounted on the spindle shaft and the stator is mounted to the spindle casting. The spindle motor has dual windings (section 6.7.1.1) which provides:

- Increased torque at higher spindle speeds
- Faster acceleration/deceleration characteristics
- Two spindle speed operating ranges without the need for mechanical parts in the drive train for range changes

A built-in pulse coder (section 6.7.1.2) enables accurate electronic spindle control, by direct digital feedback of “position signals”. This control method eliminates mechanical devices. Pulse coder signals are used for:

- Spindle orientation for ATC operations, fine and back-boring cycles
- Spindle and Z servo synchronization for rigid tapping
- Spindle speed velocity feedback

6.7.1.1 Winding Changeover Circuit

Figure 6-31 shows a typical dual winding motor configuration.

14,000 rpm spindle – High-speed range is default at power On and spindle speeds of 3,501 to 14,000 rpm. Low-speed is selected for spindle speeds of 15 to 3,500 rpm.

20,000 rpm spindle – High-speed range is default at power On and spindle speeds 4,001 to 20,000 rpm. Low-speed range is selected for spindle speeds of 200 to 4,000 rpm.

Winding changeover is initiated by magnetic power contactors (MCC1 and MCC2). The PMC initiates winding changeover with signal RCHP (**Y00.6**) and confirms winding status with RCH1 (**X00.6**) and RCH2 (**X00.7**).

- Interlocked relay circuitry prevents both power contactors from energizing at the same time.

TABLE 6-14 WINDING CHANGEOVER CONDITIONS

Range	Contactor		RCHP	RCH1	RCH2
High	MCC1 = 0	MCC2 = 1	Y00.6 = 0	X00.6 = 1	X00.7 = 0
Low	MCC1 = 1	MCC2 = 0	Y00.6 = 1	X00.6 = 0	X00.7 = 1

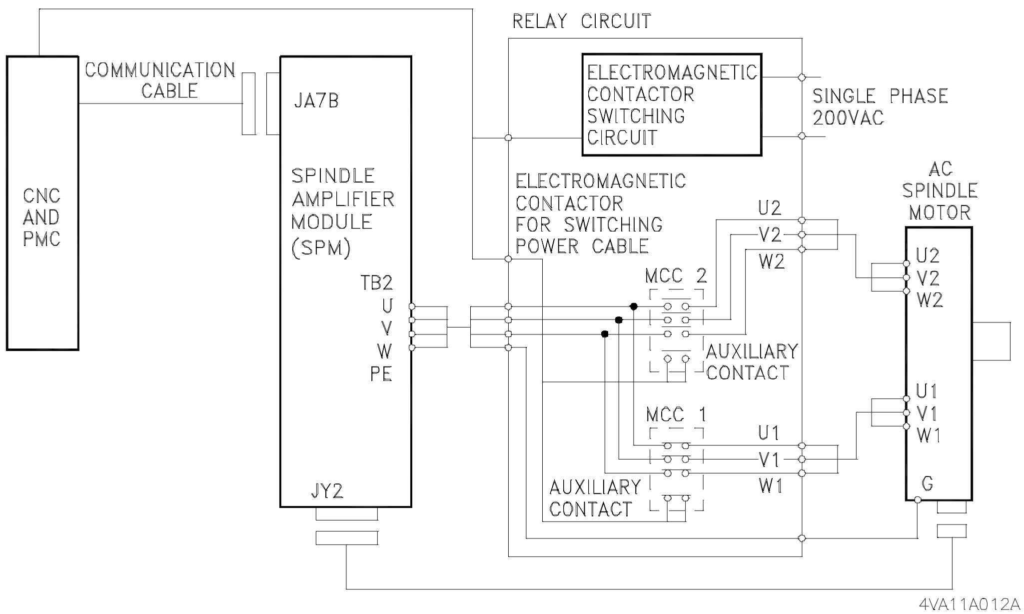


FIGURE 6-31 DUAL WINDING CHANGEOVER CIRCUIT

6.7.1.2 Pulse Coder

The orientation sequence occurs as follows:

1. The orient command (M19 or M319) is output from the CNC to the PMC.
2. The spindle decelerates to the parameter defined orientation speed.
3. The spindle rotates ½ to 2 ½ turns after reaching the orientation speed and stops at the 1 revolution signal position of the pulse coder.

Figure 6-30 shows a diagram of the pulse coder/orientation function.

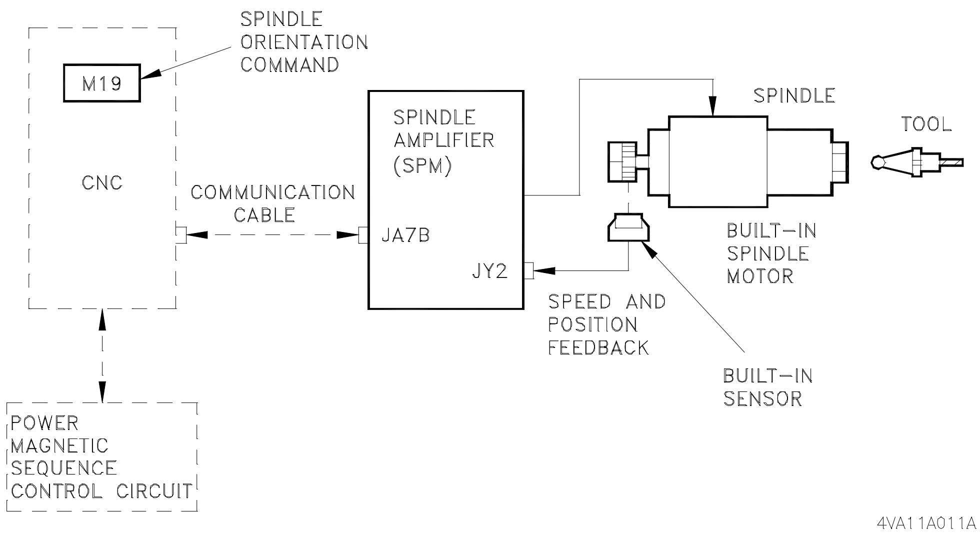


FIGURE 6-32 PULSE CODER ORIENTATION DIAGRAM

TABLE 12-14 lists the general specifications for the pulse coder.

TABLE 6-15 GENERAL PULSE CODER SPECIFICATIONS

Item	Explanation	
	Stop Position Internal Setting	**Stop Position External Command**
Position Coder	Coupled to the spindle one-to-one ratio. 1024 pulses/rotation (A-phase and B-phase signals).1 pulse/rotation (One pulse/revolution signal). Parallel transmission type of 4,000 min^{-1}, 6,000 min^{-1}, or 8,000 min^{-1},	
Detection Units	One spindle rotation (360°) is divided by 1024 x 4 (4096) pulse, i.e. 0.088° is one pulse unit (detection unit). 360°/4096 pulses = 0.088°/pulse	
Stop Position Setting	The distance between the point indicated by the position coder one rotation signal and the actual stopping position is set as a number of pulses in CNC parameter 4077.	
Precision Repeated Positioning	+/- 0.2° (Spindle Angle) Depending on the fineness of the position gain adjustment, the spindle may move for one detection unit length (0.088°) after stopping at the oriented position	
Stop Position Command		Position to be stopped can be specified by DI signal. Stops at the position of the number of pulses specified from the one rotation signal of the position coder.
Operation		When orientation command is given, spindle rotates ½ to 2 ½ turns after spindle speed reaches spindle orientation speed, and stops at the specified stop position.

NOTES:

SKETCHES:

6.7.2 Spindle Orientation

The spindle is equipped with an orientation mechanism, which stops the spindle at a specific or constant angle, known as the orient position. The spindle must stop at the orient position to ensure proper engagement of the spindle drive keys with the tool magazine grippers during ATC (Automatic Tool Change) operation. Spindle orientation is also used with the fine boring and back-boring cycles to ensure the cutting tool shifts away from the part.

6.7.2.1 Spindle Orientation Components

Figure 6-33 shows the orientation mechanism components, which includes: a two piece pulse coder ring [1] and magnetic sensor [2].

One piece of the ring is like a gear and sets up pulses detected by the magnetic sensor[2]. The other piece of the ring has a single tooth aligned with the spindle drive key and sets the “Orient Stop Position”.

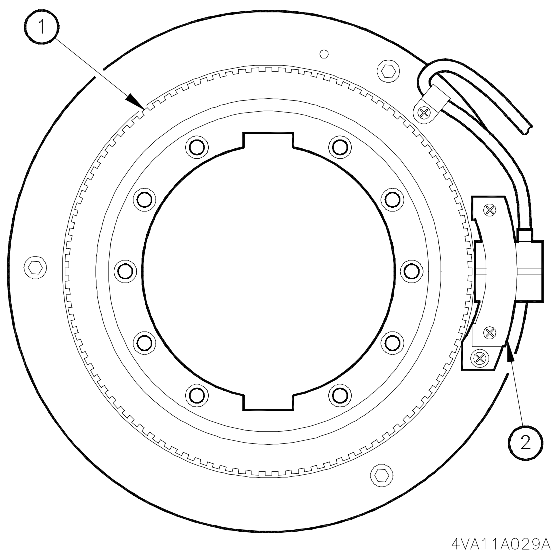


FIGURE 6-33 ORIENTATION COMPONENTS

6.7.2.2 Orient Adjustment with Parameter

This procedure sets the orient angle by inputting a value into CNC parameter 4077 (Orient Stop Position Shift Amount). The setting value of 4077 represents pulses of the spindle position coder and is input in “detection” units.

Parameter 4077 provides an angular shift from the Orient Stop Position established by the position coder ring/sensor assembly.

Determining Parameter 4077 Setting Value

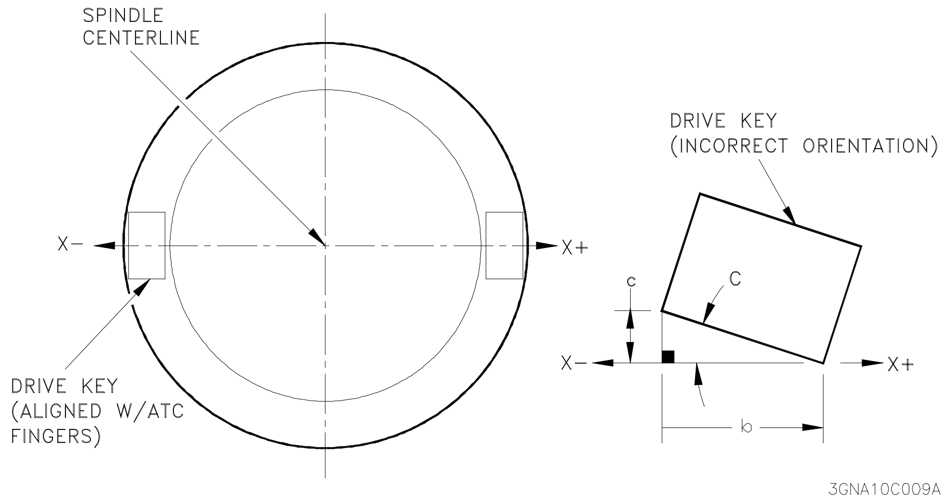
The setting value of parameter 4077 is input as detection units. The value of a “detection unit” is based on the resolution of a mechanisms feedback device. In the case of the spindle position coder, it is based on the number of position coder pulses.

Three factors must be known to determine the number of “detection units” to input for parameter 4077.

- The number of pulses per one revolution of the spindle position coder. The V55 uses a 1024 pulse/revolution position coder.
- The angle of one “detection unit”, which is determined by dividing 360 by (1024 x 4). For example, one “detection unit” equals: 360/(1024 x 4) = 0.088°.
- The angular deviation of the spindle from the “true” orient angle. This is determined by indicating the drive key on the spindle nose.

Figure 6-34, illustrates the spindle oriented parallel to the X axis, the condition of an incorrect orient angle, and the necessary formulae to determine the orient angle error. The angle error is then used to find the number of “detection units” to input into parameter 4077.

- On all V55 models, the orientation drive key orients in the –X direction.



Where:

Side c = Total indicator reading across side b

Side b = Distance (length) of indicator travel

Angle C = Angular deviation (used to determine the number of “detection units”) to correct side c error

FIGURE 6-34 ORIENTATION ANGLE CALCULATIONS

EXAMPLE: Since the V55 uses a 1024 pulse position coder, divide 360 by (1024 x 4) and determine that 0.088× equals one “detection unit”. Knowing this, we can indicate the drive key and find the value for input to parameter 4077.

If Side c = 0.056” and Side b = 0.800”

Find Angle C by: Side c ³ Side b = Tan C or 0.056 ³ 0.800 = 0.07

The inverse of Tan 0.07 = 4.0041 degrees

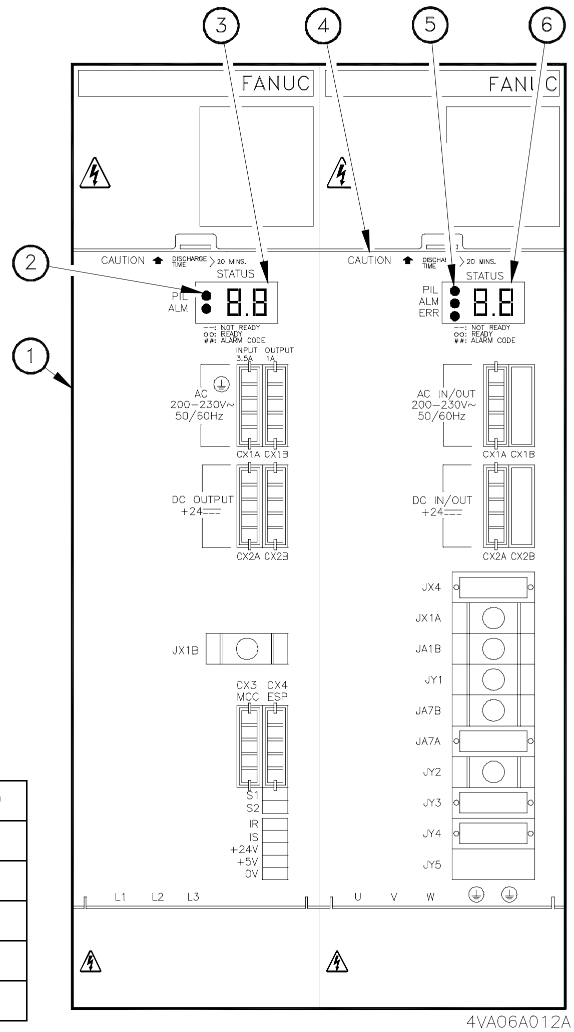
4.0041÷ 0.088 = 45.501 (the number of “detection units” / change to parameter 4077)

Operational Detail

1. Refer to The CNC Maintenance Manual for instructions related to changing parameters.
2. Changes to parameter 4077, do NOT take affect until the control has be turned Off and back On.
3. Record all parameter changes.
4. If parameter 4077 is set to zero, input the number of “detection units”. If another value is in the parameter, changed this value, by the new correction value.

6.7.3 Spindle Drive Unit (SDU)

The SDU (Spindle Drive Unit), shown in Figure 6-35,is located in the MTC (Machine Tool Cabinet) and consists of a PSM (Power Supply Module) and an SPM (Spindle Amplifier Module).



Legend

[1]	Power Supply Module (PSM)
[2]	PIL and ALM LEDs
[3]	Status Display
[4]	Amplifier Module (SPM)
[5]	PIL and ALM LEDs
[6]	Status Display

FIGURE 6-35 SPINDLE DRIVE UNIT (SDU)

6.7.3.1 Power Supply Module (PSM)

The PSM supplies power to the spindle amplifier module. It converts 3-phase AC input voltage to DC voltage. During servo deceleration, the PSM returns the generated energy to the power supply (referred to as, power supply regeneration).The PSM is mounted in the MTC and contains protection and error detection functions. Two 7-segment displays, on the front of the PSM, display an alarm number in the event of a PSM fault. PSM alarms are also displayed on the SPM.

- See appendix A for PSM alarm detail.

Table 6-16 and 6-17 presents general PSM specifications by type. Fanuc model PSM-26 is for the 14,000 rpm spindle and PSM-30 is for the 20,000 rpm spindle.

TABLE 6-16 PSM-26 SPECIFICATIONS

Power Supply	Main Circuit	AC200V/200V/230V - +10%, -15% 3-Phase 50/60Hz +/- 1Hz
	Control Power	AC200V/200V/230V - +10%, -15% Single Phase - 50/60Hz +/- 1Hz
Power Capacity	Main Circuit	37kVA
	Control Power	0.5kVA
Rated Output		26kW
Maximum Output		40Kw
Control Method		Regenerative Control (Power Supply Regeneration)
Ambient Temperature		0° to 55° C (32° to 130° F)

TABLE 6-17 PSM-30 SPECIFICATIONS

Power Supply	Main Circuit	AC200V/200V/230V - +10%, -15% 3-Phase 50/60Hz +/- 1Hz
	Control Power	AC200V/200V/230V - +10%, -15% Single Phase - 50/60Hz +/- 1Hz
Power Capacity	Main Circuit	34kVa
	Control Power	0.5kVa
Rated Output		30kW
Maximum Output		53KW
Control Method		Regenerative Control (Power Supply Regeneration)
Ambient Temperature		0° to 55° C (32° to 130° F)

6.7.3.2 Spindle Amplifier Module (SPM)

The Fanuc SPM controls the speed of the AC spindle motor using a PWM (Pulse Width Modulation) inverter to regulate the DC power converted by the PSM.

The SPM is mounted in the MTC and contains its own protection and error detection functions. Two 7-segment status displays, on the front of the SPM, display an alarm or error number in the event of a SPM fault. Some PSM alarms are also indicated on these displays.

- See appendix A for SPM alarm detail.

Table 6-18 lists the general specifications for the SPM.

TABLE 6-18 SPM-30 SPECIFICATIONS

Rated Output	133A
Circuit Control Method	Sine-wave PWM Control with Transistor (IGBT) Bridge
Feedback Method	Velocity Feedback with Position Coder
Speed Control Range	Speed Ratio 1 : 100
Speed Variation Rate	0.1% or Less of Max. Speed (Load Variation 10% to 100%)
Ambient Temperature	0° C to 55° C (32° F to 130° F)

6.8 Troubleshooting (Spindle Motor)

Initial spindle troubleshooting checks are provided in Table 6-19.

For maintenance and troubleshooting detail on the spindle motor and drive unit, refer to the CNC Maintenance Manual.

TABLE 6-19 SPINDLE MOTOR TROUBLESHOOTING

Problem	Main Causes	Checks/Remedies
Abnormal Vibration	1. Mounting or load conditions 2. Defective speed detector 3. Defective speed	1. Check workpiece mounting and cutting condition. 2. Check CNC Maintenance Manual. 3. Check the drive circuit.
Abnormal Noise	1. Defective speed 2. Bearing failure 3. Defective motor	1. Check spindle position coder. 2. Check spindle rotation for smoothness. Check spindle bearing temperature. 3. Contact your Fanuc Service group.
Motor Temperature Abnormal	1. Abnormal current 2. Load too high	1. Check drive circuit. 2. Reduce Load/Cutting condition.
Output Insufficient	1. Low input voltage 2. Drive circuit improperly set 3. Defective motor	1. Check input voltage. 2. Check and adjust setting(s). 3. Contact your Fanuc Service group.
Fuse Blown	1. Insulation failure 2. Defective drive circuit 3. Input power connection improper	1. Contact your Fanuc Service group. 2. Contact your Fanuc Service group. 3. Check input power cables and connections.
Thermal Relay Tripped	1. Motor overloaded	1. Check cutting conditions and motor circuit.
Acc/dec Time Not Correct	1. Defective drive circuit	1. Contact your Fanuc Service group.
Incorrect Rotation Speed Motor Does Not Rotate Earth Leakage Detector Activated		Motor insulation failure, Contact your Fanuc Service group.

6.9 Fluid Systems and Circuits

The spindle uses four fluid systems:

1. Hydraulics
2. Pneumatics
3. Spindle Lubrication and Cooling
4. Coolant (Cutting Fluid).

6.9.1 Hydraulic Circuit

The hydraulic system consists of a hydraulic pump, oil reservoir, and a heat exchanger unit, located inside the Hydraulic and Air Cabinet. The system provides hydraulic pressure, set to 7 MPa (1015 psi), for operation of the spindle unclamp cylinder.

Figure 6-36 shows the spindle hydraulic circuit.

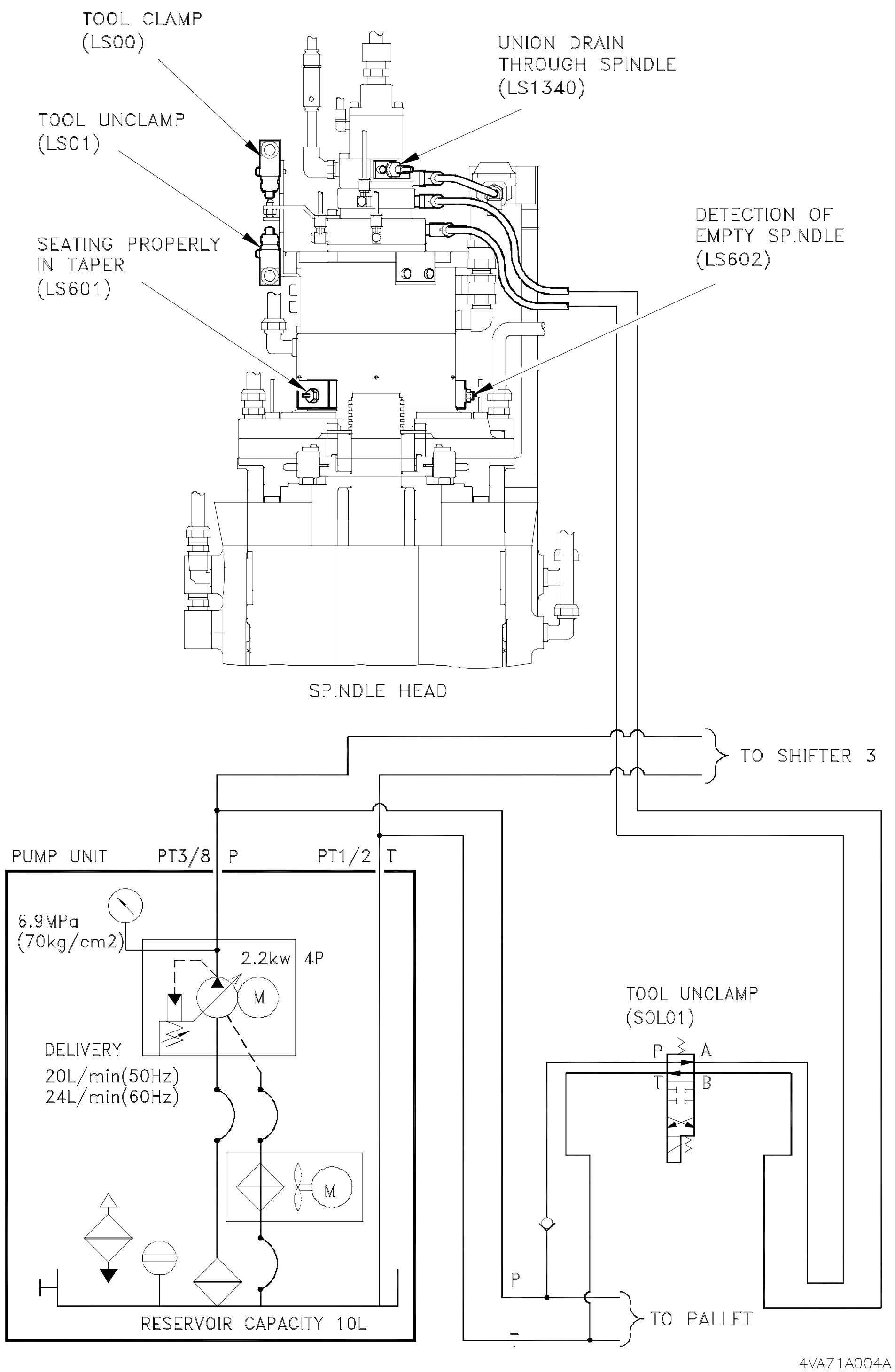


FIGURE 6-36 SPINDLE HYDRAULIC CIRCUIT

6.9.2 Pneumatics

The pneumatic system consists of a filter regulator and various air cylinders and solenoid valves located about the machine. The filter regulator and related components are located inside the Hydraulic and Air Cabinet.

System main air pressure (incoming) is set to 0.5 MPa (70 psi) with a main air pressure switch (LS905) set to 0.25 MPa (36 psi) to provide a low air alarm.

The filter regulator provides processed air for operation of the:

- ATC door - operates at 0.5 MPa (70 psi)
- Spindle air seal - operates at 0.2 MPa (30 psi)
- ATC air blast - operates at 0.5 MPa (70 psi)
- Through-spindle or external air for machining - operates at 0.5 MPa (70 psi)

Figure 6-37 shows the location of pneumatic equipment in the Hydraulic and Air Cabinet.

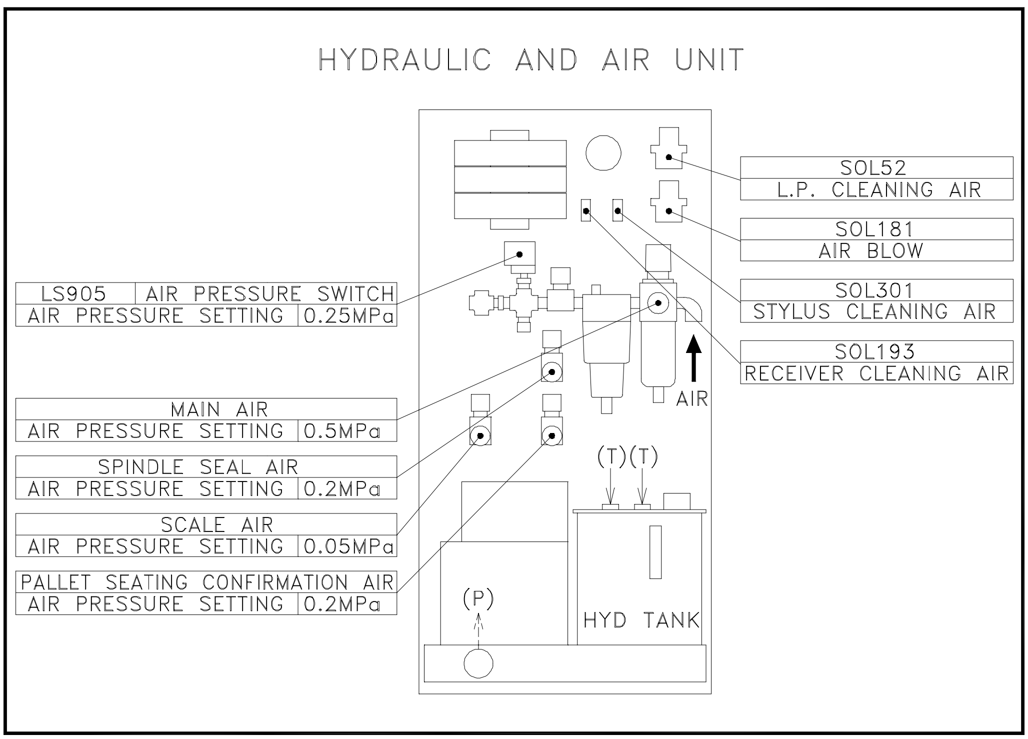


FIGURE 6-37 PNEUMATIC EQUIPMENT

6.9.3 Spindle Cooling and Lubrication

The spindle is cooled and lubricated by temperature controlled Makino Spindle Lubricant. Spindle Lubricant temperature is maintained by the oil controller to within ±1° C (±2° F) of the machine bed temperature.

Oil controller operation is controlled by PMC parameters and setup to cycle:

- Five seconds after machine power is turned On
- When the spindle is running
- 20 seconds after the spindle is stopped

An oil controller alarm or low oil level condition results in:

- A feed hold condition
- Axis interlocks turned On
- The spindle turned Off
- Coolant and spiral chip conveyor turned Off

Spindle bearing lubrication is performed by a, Makino patented, method called “under race lubrication” which jets oil through orifices in the spindle shaft and inner races of the bearing.

See section 6.9.4 for a details of the spindle lubrication/cooling system and chapter 9 for details on the oil controller.

6.9.4 Lubrication/Cooling System Detail

The spindle is both lubricated and cooled by Makino Spindle Lubricant supplied by the oil controller. The entire lubrication and cooling system includes:

- The oil controller with compressor unit and pump (P1)
- Two external, machine mounted, pumps (P2 and P3)
- Oil Tank with pump (P4)
- Machine mounted sensors for monitoring bed casting temperature

Figure 6-38 shows a block diagram of the spindle lube and cooling system.

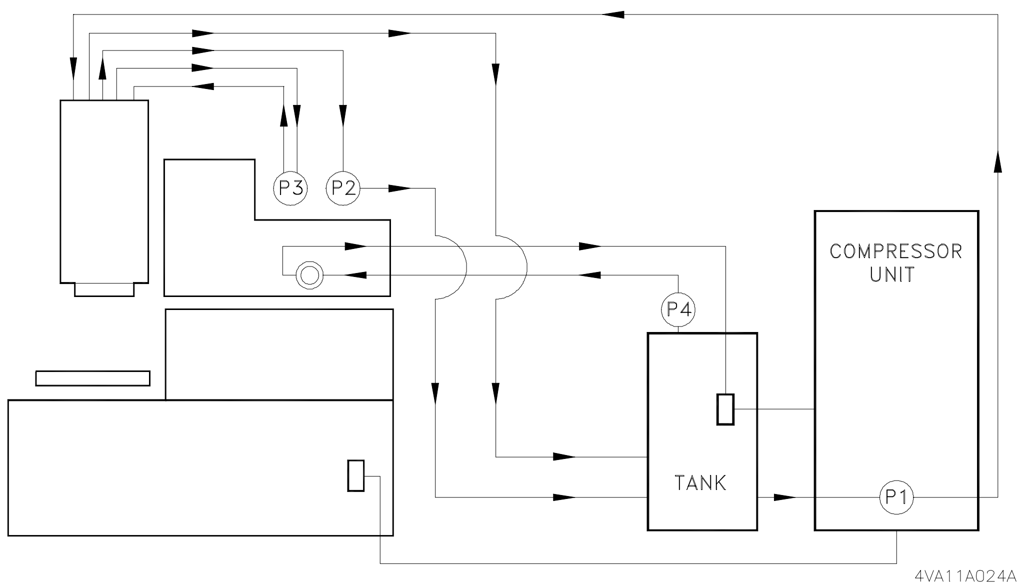


FIGURE 6-38 SPINDLE LUBRICATION AND COOLING BLOCK DIAGRAM

Pump P1, mounted in the compressor, draws oil from the tank and supplies it to the spindle head.

Pump P2, mounted vertically on back of column, pulls oil from the area outside of the stator and returns it to the tank.

Pump P3, mounted at an angle on back of column, draws oil from the center area of the spindle rotor and returns it to the spindle.

Pump P4, mounted on the tank, circulates oil through the axes ball screws core and TAC bearings, Z axis ball screw casting, and the column cooling covers.

Lubricant piping is of two basic types; **L** (Lubrication) ports which circulate lubricant to areas of the spindle/machine and **V** (Vacuum) ports which draw off of suction lubricant from areas of the spindle.

Figure 6-39 shows L and V port connections at pumps P2 and P3.

Figure 6-40 (pg. 6-65) shows L port piping

Figure 6-41 (pg. 6-67) shows V port piping.

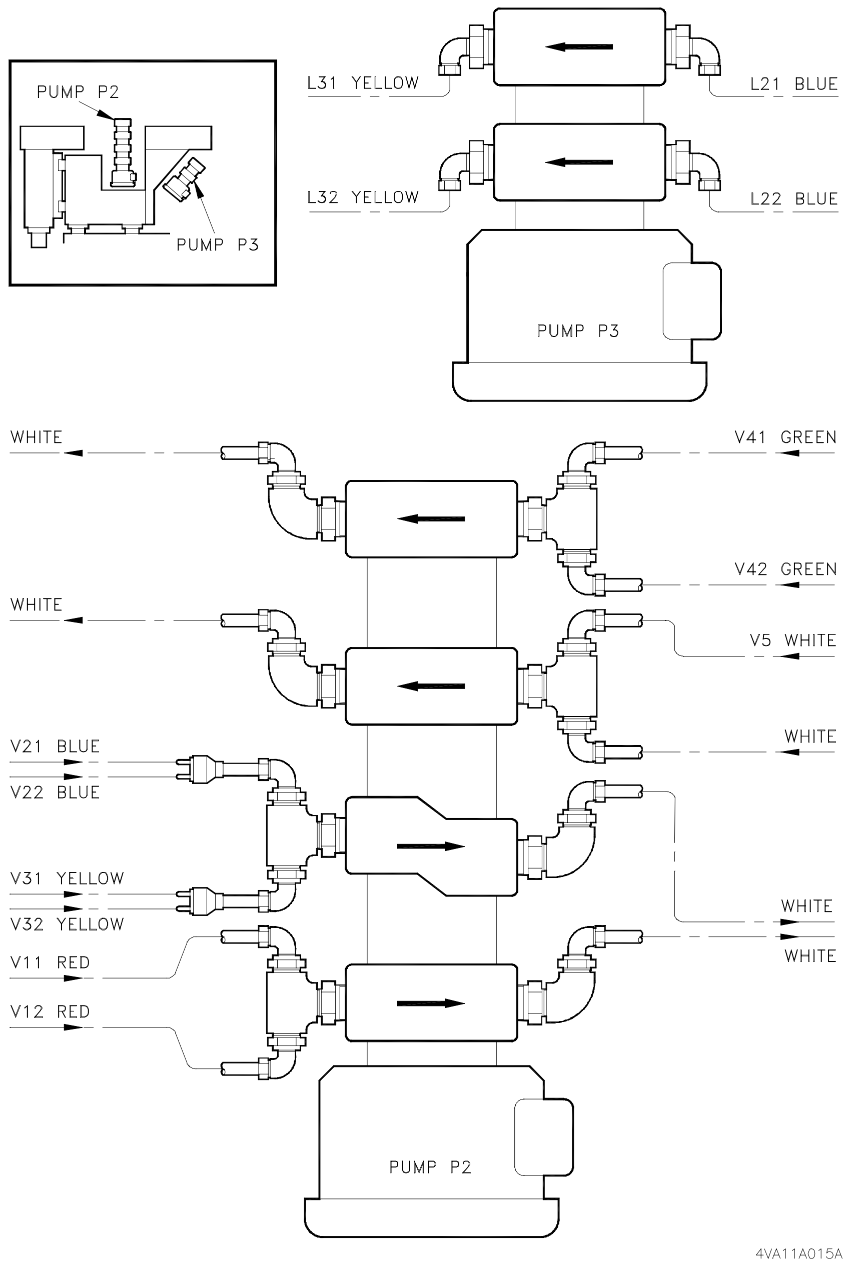


FIGURE 6-39 PUMPS P2 AND P3 CONNECTIONS

L Port Piping

The **L** port piping, (Figure 6-40), circulates Makino Spindle Lubricant from various areas of the spindle head and is basically the portion of the system that provides cooling for the spindle assembly.

Ports L11 and L12, (left side of spindle head) supply lubricant to the upper spindle (pump P1 on the oil controller), cooling the inner diameter of the spindle. Piping is red AS35-10 lines.

Ports L21 (left side of spindle head), and L22 (right side) pulls lubricant from the upper spindle (pump P3 back of column). Piping is blue AS35-10 lines.

Ports L31 (left side of spindle head) and L32 (right side) supplies lubricant to the lower spindle area (pump P3 back of column). This lubricant cools the lower spindle bearings and is piped by yellow AS35-10 lines. The line to port L31 is teed to supply lubricant to the TSC (Through-Spindle-Coolant) rotary coupling bearings at port L41-1 (right side of spindle head). The lubricant exits this area through port L41-2 and is teed back into port L31.

Ports L61 (left side of spindle head) and L62 (right side) pulls lubricant from the mid section of the spindle head, in the area of the motor stator (pump P2 back of column) and returned it to the tank. Piping is green AS35-10 lines.

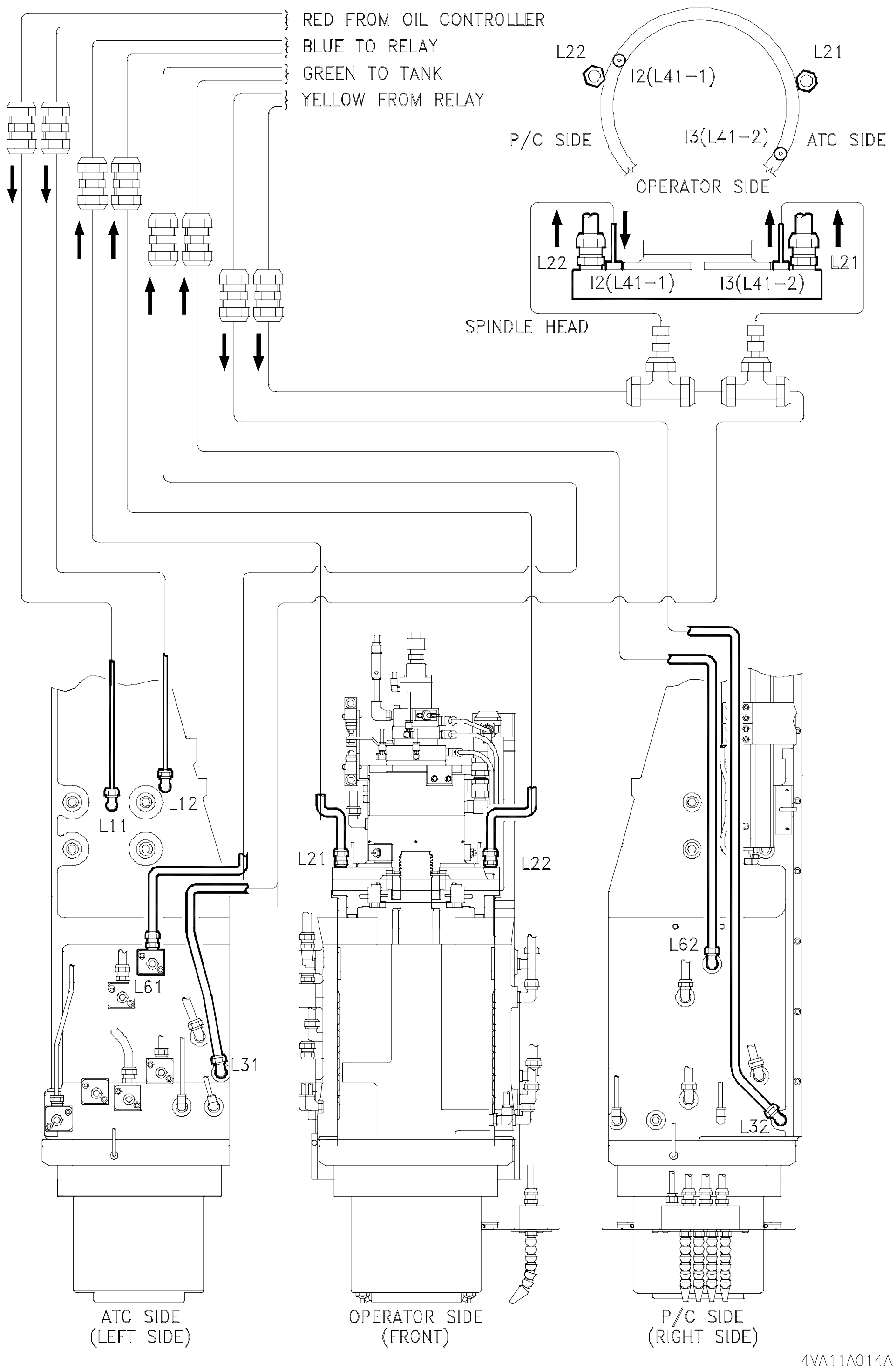


FIGURE 6-40 L PORT SPINDLE LUBRICATION

V Port Piping

The V port piping (Figure 6-41) pulls Makino Spindle Lubricant from various areas of the spindle head. The vacuum helps overcome the rotational effects and keeps the lubricant flowing, while suctioning excess lubricant at sealing areas.

Ports V11 (left side of spindle head) and V12 (right side) pull lubricant from the lower spindle head (bottom stage pump P2), providing lubrication to the lower spindle bearings. Piping is red AS4 50-04 lines.

Ports V21 (left side of spindle head) and V22 (right side) pull lubricant from the upper spindle head (lower middle stage pump P2). These ports are in the upper bearing case housing spacer and lubricate the upper spindle bearing. Piping is blue AS4 50-04 lines.

Ports V31 (left side of spindle head) and V32 (right side) pull lubricant from the upper spindle head (lower middle stage pump P2). These ports are in the upper bearing case housing spacer and lubricate the upper spindle bearing, spindle shaft and related components. Piping is yellow AS4 50-04 lines.

Ports V41 (left side of spindle head) and V42 (right side) pull lubricant from the TSC rotary coupling (top stage pump P2). These ports are in the bearing retainer and provide lubrication to the rotary coupling bearings. Piping is green AS4 50-04 lines.

Port V5 (right side of spindle head) pulls lubricant from the top of the spindle (upper middle stage pump P2). This port is in the cylinder case and lubricates the upper spindle bearing. Piping is white AS4 50-04 line.

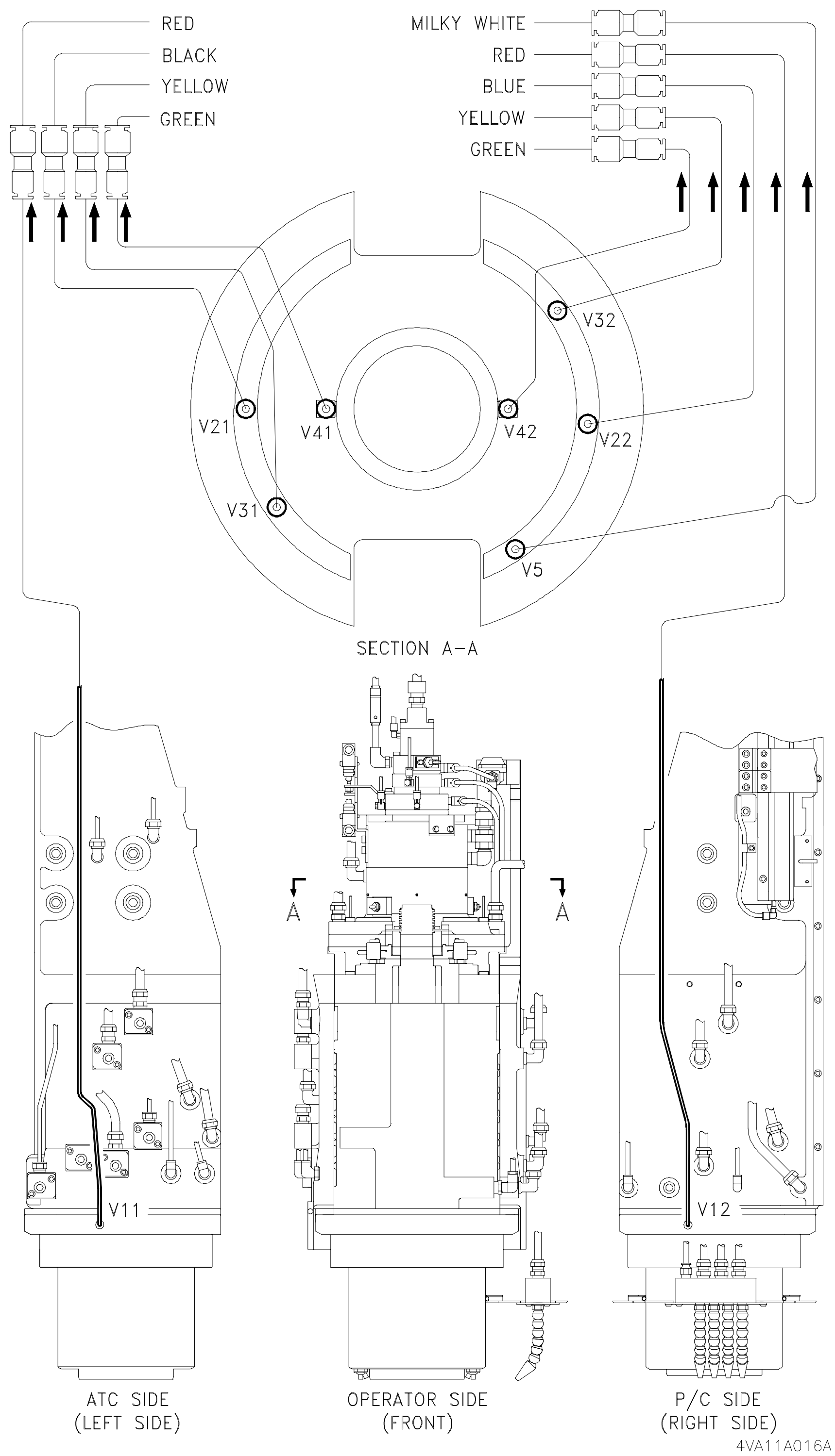


FIGURE 6-41 V PORT SPINDLE LUBRICATION

6.9.5 Coolant Delivery Systems

The V55 11A spindle comes with; TSC (Through Spindle Coolant) (liquid or air) and two external coolant systems: four flexible hoses (for longer tools and four swivel nozzles for shorter tools.

6.9.5.1 TSC (Through Spindle Coolant)

TSC (Through Spindle Coolant) is a method of applying coolant to the tool's cutting tip by passing coolant internally through the spindle, through the tool holder retention knob and tool holder and finally through inner drillings in the tool. The use of TSC is essential in high-speed or other machining processes where normal flood coolant is unable to reach the tool's cutting tip. TSC is more effective in flushing chips from the tool, which takes heat away from the cutting process. General benefits of using TSC are: machining at higher speeds, better surface finishes, better control of part tolerances, effective heat dissipation, and improved tool life.

- TSC and the design of the sealing rod mechanism requires use of special tool holders and retention knobs. See TSC - Tool Holder Retention Knob (pg 6-70) for details.

Through Spindle Coolant Mechanism

CAUTION

Through Spindle Coolant Assembly

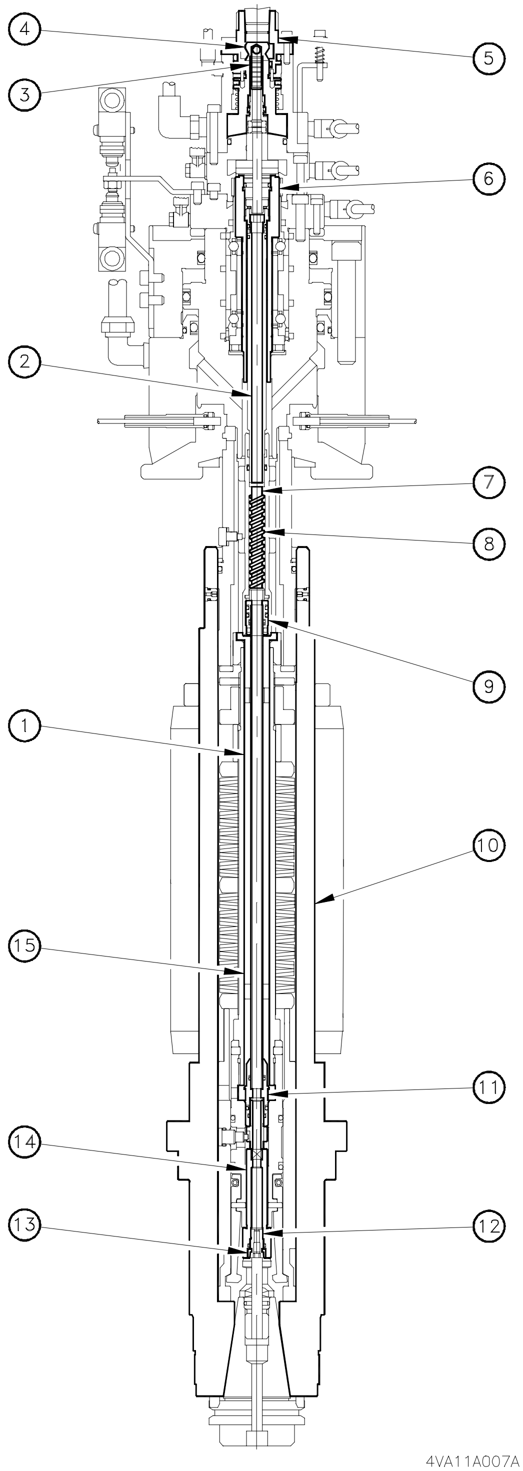
The through spindle coolant assembly is an integral part of this high-speed spindle assembly. Removal and installation should be performed by Makino, in a clean room environment. Maintaining critical alignments and balance, during assembly, is extremely IMPORTANT. Makino requests that our customers do NOT attempt to repair this assembly.

The TSC mechanism starts with the rotary coupling located at the top of the spindle assembly. The main components of the TSC mechanism are shown in Figure 6-42.

The TSC assembly contains numerous seals and o-rings to prevent coolant leakage into the center of the draw bar that would contaminate the spindle cooling lubricant.

Due to the critical alignments and balance conditions of the high-speed spindle, the only portion of this mechanism that is repairable in the field is the rubber seal in the end of the sealing rod.

- See section 6.9.5 for instructions on replacing the sealing rod.



Legend

[1]	Coolant Pipe
[2]	Coolant Rod
[3]	Spring
[4]	Piston
[5]	Cylinder Cap
[6]	Rotating Shaft
[7]	Coolant Rod Support
[8]	Spring
[9]	Joint
[10]	Spindle
[11]	Joint
[12]	Inner Sleeve
[13]	Rubber Seal
[14]	Sealing Rod
[15]	Draw Bar

FIGURE 6-42 TSC MAIN COMPONENTS

TSC - Tool Holder Retention Knob

TSC requires special; tool holders, retention knobs, and cutting tools designed to allow coolant to pass through the center. Figure 6-43 shows retention knob details.

A rubber seal in the end of the sealing rod seals between the retention knob and TSC mechanism. To prevent damage to the seal and provide a good seal, the end of the retention knob [1] must be a ground surface.

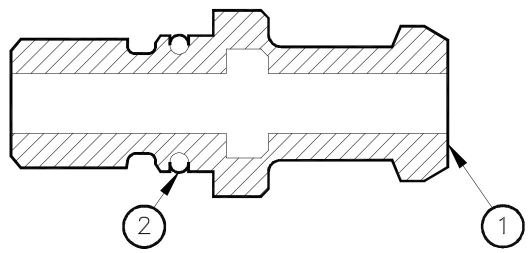


FIGURE 6-43 TSC RETENTION KNOB

An O-ring on the retention knob shank [2], ensures a good seal between the tool holder and the retention knob.

Sealing Rod Seal Replacement

Inspect the seal on the sealing rod daily and replace immediately when any signs of wear or damage are indicated. In addition to a visual inspection, other signs of a damaged seal are:

- Excessive coolant flow from the spindle taper during a tool change; as the result of a coolant build-up in the area of the collet fingers.
- Coolant contaminated spindle lubricant.

Table 6-20 lists the tools and replacement parts needed before starting the sealing rod seal removal and installation procedure.

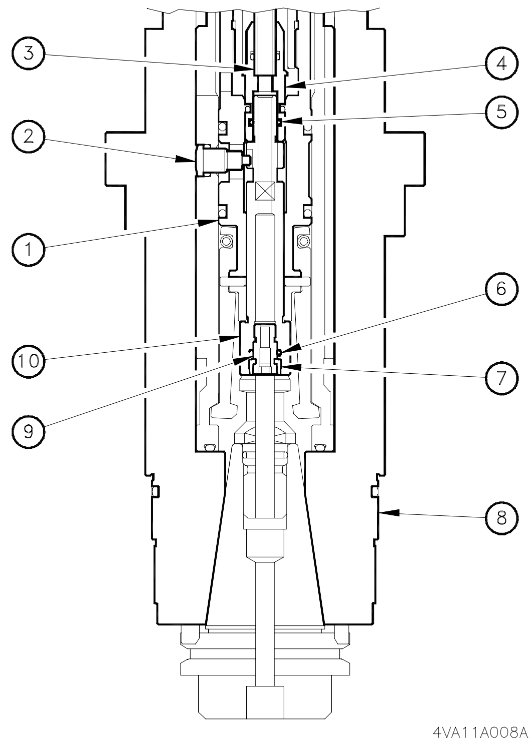
TABLE 6-20 SEALING ROD – TOOLS AND PARTS

Name	Makino Part No.	Description and Use
Spindle Catch Jig	4V200A003A	Attaches to spindle bearing retainer to prevent spindle rotation.
T- Wrench	13M71B409=1	Threads into end of inner sleeve for sealing rod assembly removal and installation.
O-ring	P9 (2 Required)	Replacement for O-rings [5] and [6] (Figure 6-44).
Rubber Seal	13M11G704	Replacement for Seal [4] (Figure 6-44).
1. The spindle catch jig and T-wrench are supplied with the machine. The replacement O-rings and seals must be purchased from Makino.		

Figure 6-44 shows the sealing rod assembly that must be removed to replace the seal. The parts that make-up the assembly include the sealing rod [10], inner sleeve [9], O-ring [6], and rubber seal [7].

Other parts important to the sealing rod assembly, but not part of the assembly, include the pin [2] and O-ring [5].

- During sealing rod assembly removal and installation, follow the procedure carefully to avoid damaging the pin [2] or O-ring [5].



Legend

[1]	Draw Bar	[6]	O-ring
[2]	Pin	[7]	Rubber Seal
[3]	Coolant Pipe	[8]	Spindle
[4]	Joint	[9]	Inner Sleeve
[5]	O-ring	[10]	Sealing Rod

FIGURE 6-44 SEALING ROD ASSEMBLY

Sealing Rod Assembly Removal

Use this procedure to remove the sealing rod assembly.

1. Position the Z axis to a convenient height for working under the spindle.
   - A minimum clearance of 210mm (8.3") plus the distance the T-wrench extends below the spindle face is required.
2. Press [TOOL UNCLAMP], to clamp the spindle without a tool.
3. Inhibit X, Y, and Z axis motion by:
   A. Press the [CUSTOM] key.
   B. Press page [↓], to display page 2 of the PO screen.
   C. Using the cursor key, select MACHINE LOCK.
   D. Press the [ON] softkey, to activate Machine.
   E. Press any other Function key to exit the Custom side.
4. Select the MDI Mode and Inhibit spindle rotation by:
   A. Using the alpha-numeric keypad, key-in ‘S0’.
   B. Press the [EOB] key.
   C. Press the [INSERT] key.
   D. Press Cycle [START].
   - Custom side Alarm 07020 is generated and inhibits starting the spindle by the [SPINDLE START] button.
5. Attach the spindle catch jig to the spindle bearing retainer (Figure 6-45)
   A. Remove the two M6 plugs [3] adjacent to coolant nozzle [4].
   B. Place one end of the jig [2] over a spindle drive key [1] and the other end around coolant nozzle [4] (with adjacent M6 holes).
   C. Secure jig [2] with two M6x12 socket head cap screws [3].

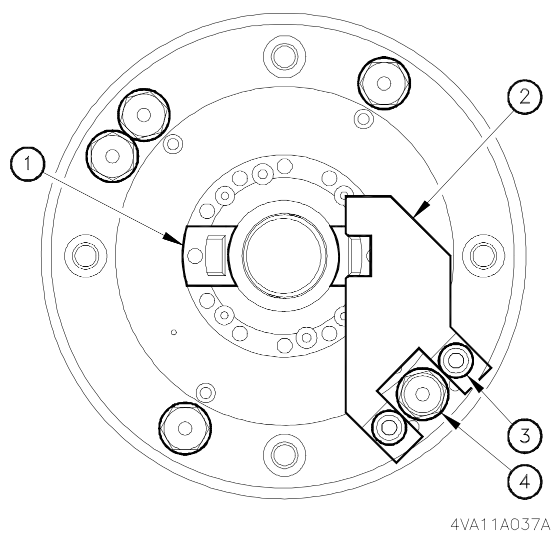


FIGURE 6-45 SPINDLE CATCH JIG

T-wrench Installation and Use

CAUTION

Do not over tighten the T-wrench. If over tightened it may break off inside the sleeve. Do not apply side-to-side force to the T-wrench, during use. Side force may break off the T-wrench inside the sleeve.

6. Thread the T-wrench [3] into the inner sleeve [2], see Figure 6-46.
7. Mark the radial location of the T-wrench handle to the spindle.
8. Push straight up on the T-wrench (about 8mm (0.3")) and then rotate the T-wrench 90° CW to align the “open slot” with the pin [1].
9. Press [TOOL UNCLAMP], to unclamp the spindle.
10. Remove T-wrench and attached sealing rod assembly, from spindle.

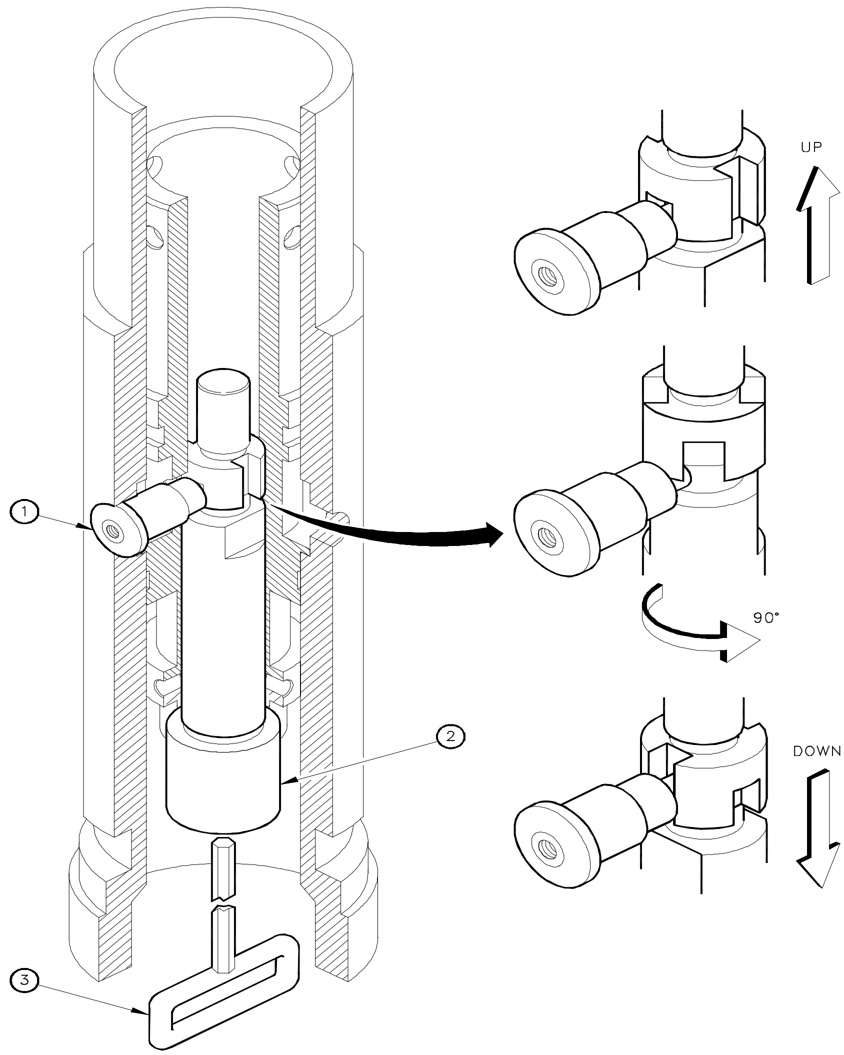


FIGURE 6-46 SEAL REMOVAL

Seal Replacement

With the sealing rod assembly removed from the spindle, replace the O-rings and rubber seal as follows.

1. Using a 4mm hex wrench, unscrew inner sleeve [1] from sealing rod [2].
2. Remove old O-ring [3] and rubber seal [4].
3. Thoroughly clean and dry both the inner sleeve [1] and sealing rod [2].
4. Inspect all sealing surfaces, to ensure that no scratches, nicks, or other damage to either part exists.
   - Replace any damaged parts.
5. Apply a quality O-ring lubricant to the new O-ring [3] and rubber seal [4].
6. Install O-ring [3] in sealing rod [2] and the rubber seal [4] onto the inner sleeve [1].
7. Being careful not to pinch O-ring [3], thread inner sleeve [1] into sealing rod [2] and tighten securely.
   - Use Loctite 242/blue, or equivalent, on inner sleeve threads.
8. Looking up into the spindle, visually inspect the O-ring used to seal the upper portion of the sealing rod [2].
9. Replace this O-ring if there are any signs of wear or damage.

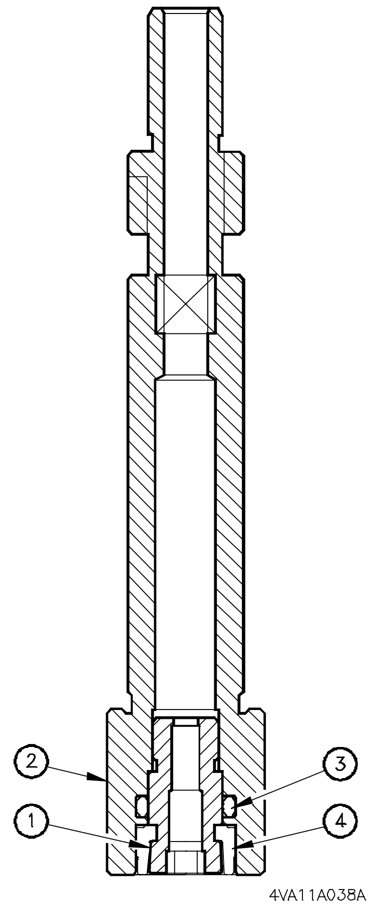


FIGURE 6-47 SEALING ROD ASSEMBLY

NOTES:

SKETCHES:

Sealing Rod Installation

CAUTION

Sealing Rod Installation

When installing the sealing rod assembly, it is VERY IMPORTANT to properly align the sealing rod slots with the draw bar pins. Improper alignment will result in damage to the draw bar pins during operation of the spindle clamp/unclamp mechanism. Draw bar pin replacement requires removing the entire draw bar assembly from the spindle.

1. Make sure the spindle is in an unclamped state.
2. Thread the T-wrench into the inner sleeve.
3. Apply a thin coat of quality O-ring lubricant to the upper end of the sealing rod.
4. Install the sealing rod assembly into the spindle (Figure 6-48).
   - A. Carefully insert the end of the sealing rod into the coolant pipe joint to avoid pinching or cutting the upper O-ring.
   - B. While applying slight upward pressure, slowly rotate the T-wrench [3] clockwise until the “open” sealing rod slots align and engage with the draw bar pin [1].
5. Press [TOOL UNCLAMP], to clamp the spindle.
6. Push the sealing rod upwards, as far as it will go (about 8mm (0.3")), then rotate the T-wrench 90° clockwise.
7. Relax the upward pressure, allowing the sealing rod to move downward (by spring pressure) and seat the draw bar pins in the “closed” slots of the sealing rod [2].
8. Unscrew the T-wrench from the inner sleeve.
9. Remove the spindle catch jig.
10. Clear the Custom alarm 07020 and turn Machine Lock Off:
    - A. Pressing the [CUSTOM] key.
    - B. Pressing the [ALARM] softkey.
    - C. Pressing the [ALARM RESET] softkey.
    - D. Pressing [PO].
    - E. Pressing page [↓], to select page 2 of the PO screen.
    - F. Using the cursor keys, to select MACHINE LOCK.
    - G. Pressing the [OFF] softkey.
    - H. Press any other function key to exit the Custom side.

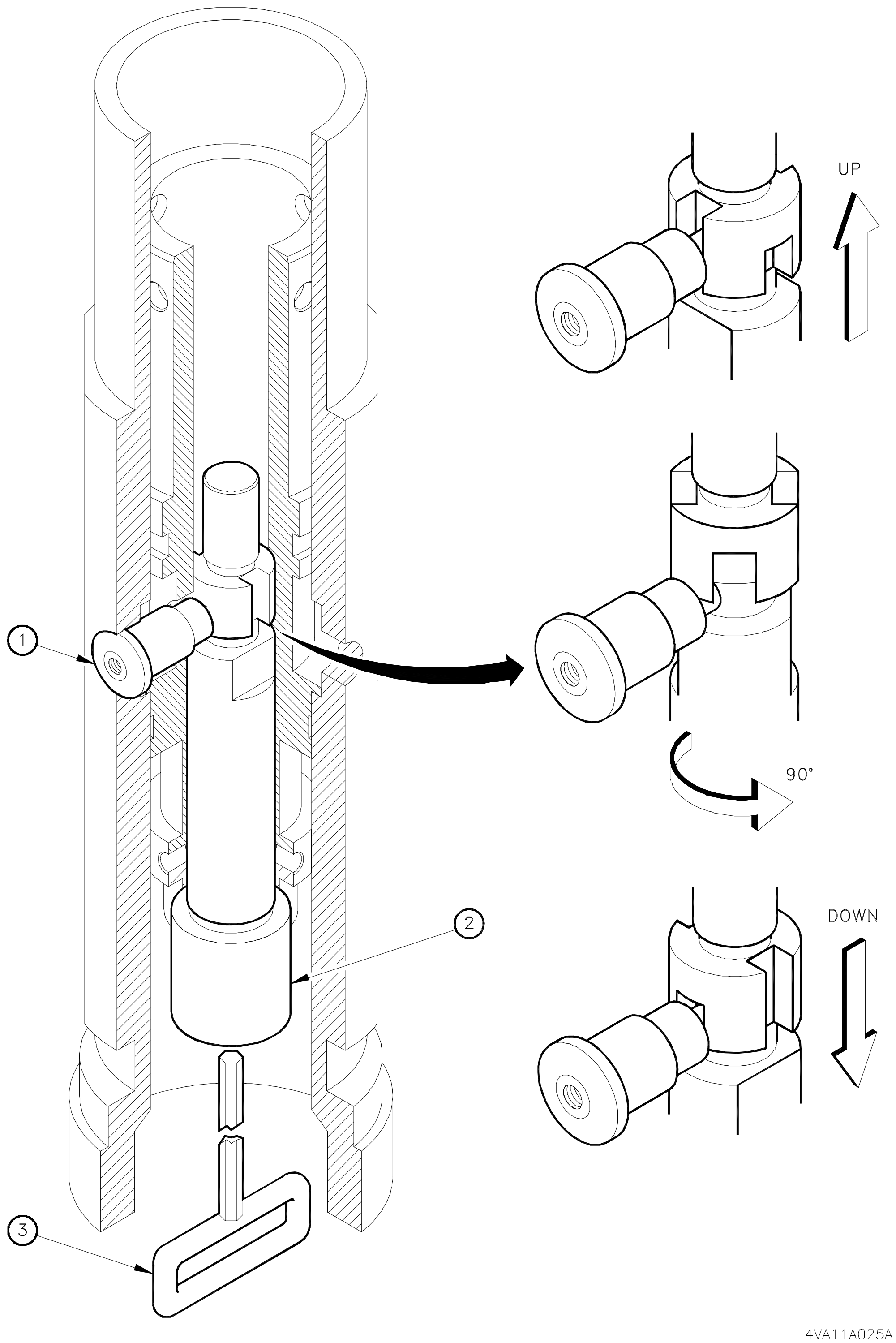


FIGURE 6-48 SEALING ROD INSTALLATION

6.9.5.2 External Nozzle Coolant

The standard external nozzle coolant system consists of eight nozzles for directing coolant externally to the cutting tool.

Four flexible hose nozzles are located to the right of the spindle. These hoses are generally used with longer tools when coolant can not be effectively applied using the fours nozzles located around the spindle.

- The discharge rate is: 50 L/min (13.2 gal/min)

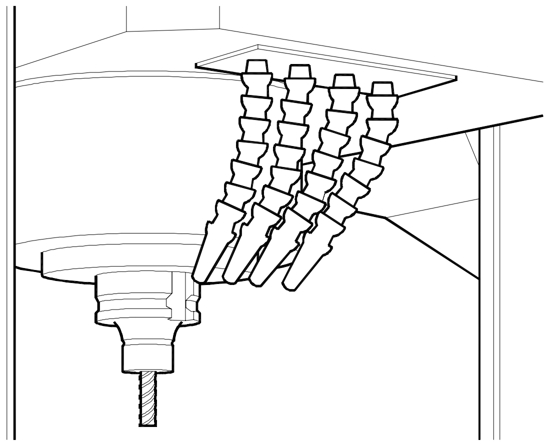


FIGURE 6-49 EXTERNAL NOZZLE COOLANT

Four swivel nozzles are located equally spaced around the spindle in the bearing retainer. These nozzles are generally used with shorter tools and effectively apply coolant around the tool.

Because of the smaller nozzle orifice, these nozzles may become clogged and require disassembly and cleaning, discussed in section 6.9.5.2.

Swivel Nozzle Cleaning

The nozzle assembly contains a ball and spring to stop flow when the coolant is turned Off.

If any nozzle tends to leak after coolant has been turned Off, slightly stretch spring [4] so that it applies more force against ball [3].

Use Figure 6-50 and the following procedure to disassemble, clean, and assemble any of the four swivel coolant nozzles.

1. Unscrew the nozzle [5] from the insert [2].
2. Capture the O-ring [6], valve case [1], spring [4] and ball [3] as the nozzle is unscrewed from the insert [2].
3. Clean all components, disassembled in Step 2., in a solution suitable for removing cutting fluid residue.
4. If necessary, use a pipe cleaner and clean the inside of the insert [2].
5. Re-assemble all components as shown in Figure 6-50.
6. Screw the nozzle [5] into the insert [2].

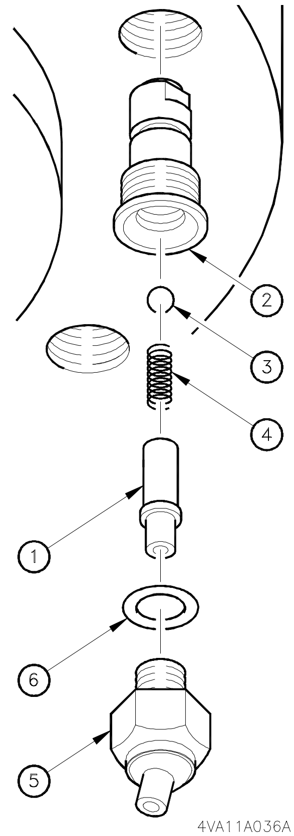


FIGURE 6-50 SWIVEL NOZZLE ASSEMBLY

6.10 Upper Spindle Cover Removal

The upper spindle cover [1] (Figure 6-51) protects spindle mounted components from exposure to chips, coolant, and undesired contact during automatic operations. Removal of the upper spindle cover is required to access these components for adjustment.

To remove the upper spindle cover:

1. Remove the 13 (M4×5) cross-head screws [2]
2. Lift upper cover up and away from bottom cover [3].

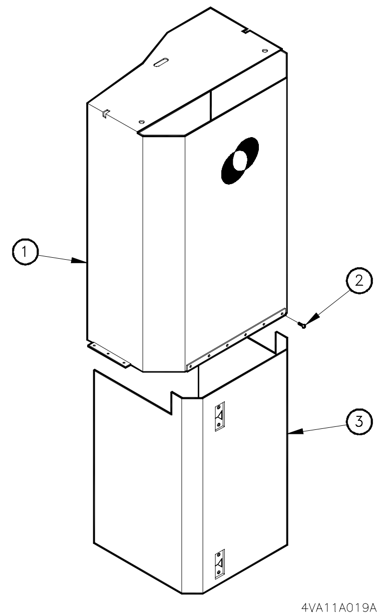


FIGURE 6-51 UPPER COVER REMOVAL

6.11 Preventive Maintenance

Check the following items, at the recommended frequencies, to ensure proper machine performance, accuracies, and capabilities, are and maintained, throughout its life.

6.11.1 Daily Checks/Maintenance

1. Clean the spindle taper with cleaning tool. Dirt and/or chips in the taper may cause the tool holder to “stick” and nick the spindle taper. Dirt or chips will also affect tool repeatability.
2. Inspect the Through Spindle Coolant sealing rod seal, see section 6.9.
3. Check the system hydraulic and main air pressures, see section 6.9.

6.11.2 Other

If the machine is not to be used for a long time:

1. Clean the machine and coat all machined (non painted) surfaces with a rust preventive oil.
2. Clamp a tool holder in the spindle.

PM Schedule

This schedule is based on an 8 hour day, 40 hour week. Therefore one year is approximately 2,000 hours of operation.
See chapter 3 for more detail and information pertaining to PM and Lubrication of the machine tool components, recommended oils, greases, fill points, frequencies, etc.

NOTES:

SKETCHES:

Chapter 7 Feed Axis Unit

4V20A,30A,40A Type

Standard Machine and Axis

Configuration

Makino V55 High-speed Vertical
Machining Center

MAKINO

Chapter 7
Feed Axis Unit

Contents

7.1 Overview

The V55 is a ram type vertical machining center. The X axis is formed by the saddle which is mounted on top of the column. The Y axis is formed by the table which is mounted on top of the bed casting. The Z axis (ram) is mounted to the front of the saddle.

Axes sliding members are mounted to LM (Linear Motion) guide ways. LM guides provide: faster rapid traverse rates, higher feedrates, reduced lost motion and friction, and elimination of slip-stick characteristics.

Hardened precision ball screws and Fanuc AC servo motors and drive systems are used to drive and control the axes. These motors have sharp acceleration/deceleration characteristics, excellent torque output and minimum maintenance requirements.

Each axis is designed with a reference point return function facilitating operation and programming. This function ensures repeatability and allows for accurate positioning or repositioning of the axes, when restarting the machine tool.

7.2 Axis Configuration

The V55 axes configuration includes the three basic axes of the machine coordinate system X, Y, and Z.

The machine is designed to provide a work cube or machining envelope (Figure 7-1) that is 900mm (35.4") in the X axis plane, 500mm (19.7") in the Y axis plane, and 450mm (17.7") in the Z axis plane.

This range of movement is provided by the design and layout of the sliding members of the machine tool. A description of the sliding members and their relationship to the coordinate system is shown in Figure 7-2 and described below

7.2.1 X Axis

The X axis is formed by the saddle. The saddle is mounted on top of the column and moves right and left along the length of the table.

The X axis references to the extreme + end of its stroke, to the right hand side of the machine.

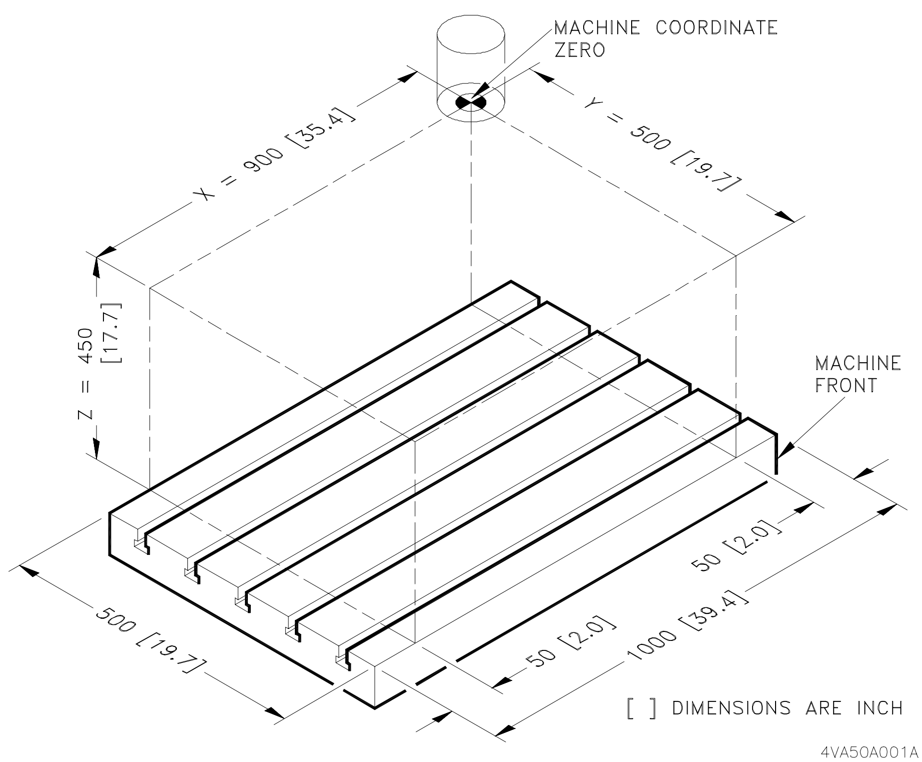


FIGURE 7-1 WORK CUBE AND MACHINE COORDINATE SYSTEM

7.2.2 Y Axis

The Y axis is formed by the table. The table is mounted to the bed casting and moves in and out, perpendicular to the X axis.

- The Y axis references to the extreme + end of its stroke, toward the operator.

7.2.3 Z Axis

The Z axis is formed by the ram. The ram is mounted to the front of the saddle and moves up and down (toward and away from the table).

- The Z axis references to the extreme + end of its stroke, away from the table.

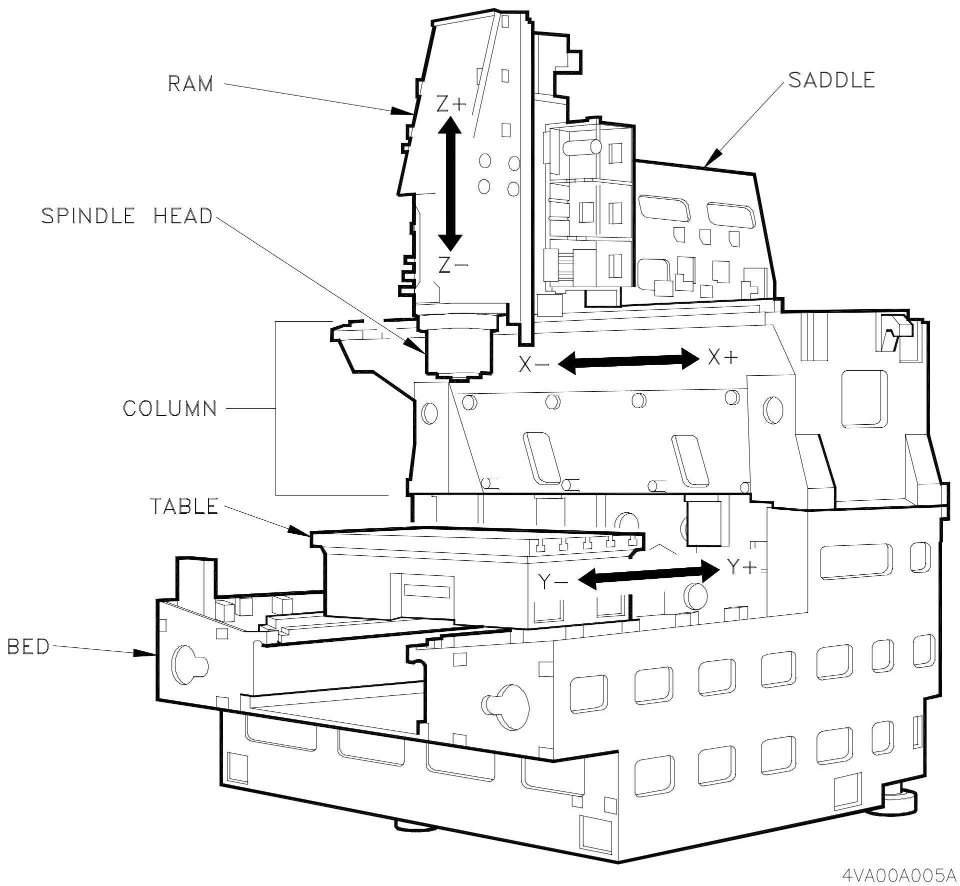


FIGURE 7-2 AXIS CONFIGURATION

7.3 Principle of Operation

Axis positioning commands are input to the CNC; manually using the jog functions or hand wheels; by CNC commands in the MDI, TAPE, and MEMORY Modes; or through a DNC link.

All axis positioning commands are read by the CNC and sent to the position control software for processing. The commanded movement (distance) is calculated by the position calculating circuit and entered into an error counter. The error counter value is compared to the feed back signal from the motor pulse coder. The position control circuit then issues a command to reduce the difference between the value in the error register and feed back signal to zero.

The “error” between command and feedback is converted into a signal and amplified by an AC servo amplifier rotating the motor. The speed feed back signal is converted to F/V and fed to the amplifier to change the turn-on angle and control the axis speed.

Rotation of the servo motor is transferred into linear axis movement via the ball screw, which is coupled to the servo motor. The ball screw is the axi driving member and moves the axis component (saddle, table, or ram). Each component is attached to the ball screw at the ball nut. During ball screw rotation the ball nut and the axis component are moved along the precision screw.

Each axis component is mounted to sliding members. The V55 uses LM (Linear Motion) guides as the sliding members for all axes. Sliding members maintain the axis component's geometry (squareness, height, parallelism) related to other axis components and ensures that the axis travels accurately along its coordinate plane.

7.3.1 Feed Drive Circuit

The axis drive circuit is shown in Figure 7-3.

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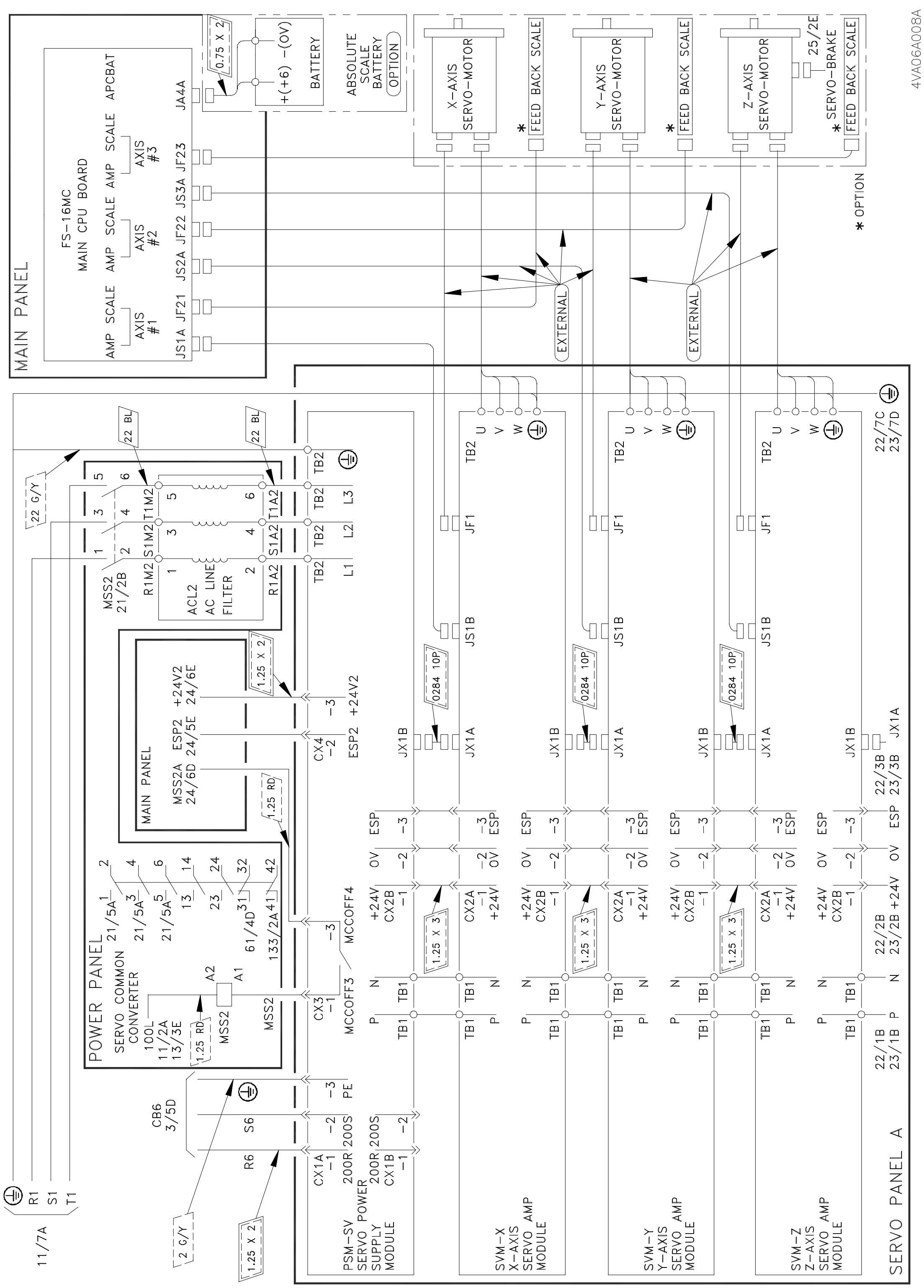


FIGURE 7-3 AXIS DRIVE CIRCUIT

7.4 Axis Design

A basic knowledge of axis design and design principles is useful in understanding the feed axis system. Axis design requires sliding members that move or slide and driving members that cause or drive the sliding members movement.

On the V55 sliding members consist of the castings and related components that make up the saddle, table, and ram and form the X, Y, and Z axes respectively. Sliding members are mounted to components, called LM (Linear Motion) guides (section 7.4.2.3) that allow smooth and straight axis motion.

Driving members must move or position the sliding members in an accurate and repeatable manner. The driving members are the heart of the feed axis system and discussed in section 7.4.1.

7.4.1 Driving Member Components

Driving members move and position an axis. The components of the drive system are mechanical, electrical, and electronic assemblies.

7.4.1.1 Mechanical Components

The basic mechanical driving components are shown in Figure 7-4.

The ball screw [1] is located and supported by bearings [6] and [7] mounted on the base member, typically between and in-line with the ways. The type of bearings and method of ball screw support may vary with different systems. On the V55, the ball screw [1] is supported at both ends by TAC bearings.

A coupling device [4] connects the ball screw [1] to the servo motor [5], transferring the rotational forces through the ball screw [1]. The sliding member [2] of an axis is mounted to the ball nut [3]. As the ball screw [1] rotates the ball nut [3] and sliding member [2] move linearly along the screw.

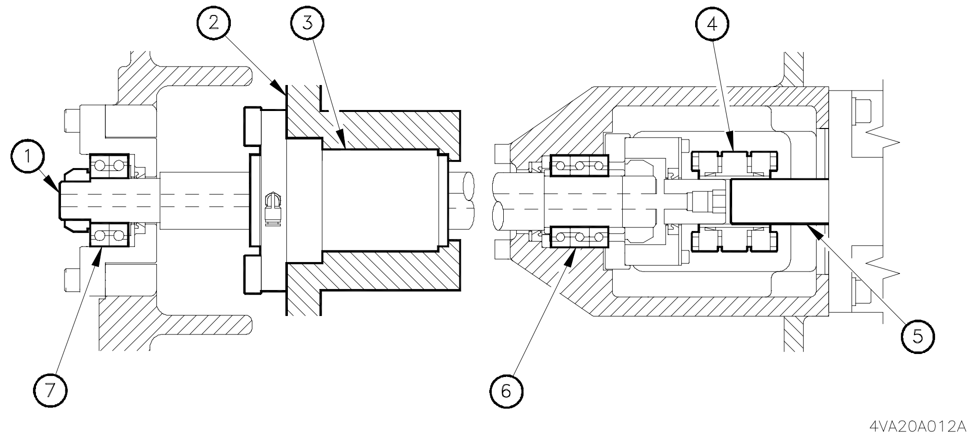


FIGURE 7-4 AXIS MECHANICAL CONSTRUCTION

Driving Components

1. This basic operating principle is true for all V55 axes drive systems. The Z axis is the gravity axis and has some differences in design and construction. Axis specifics are discussed in detail, when relevant.
2. TAC (Thrust Angular Contact) bearings are specifically designed for ball screw applications. When replacing the TAC bearings, be certain that bearing orientation is correct.

7.4.1.2 Electrical Components

The main electrical components of the V55 servo system are the Fanuc α Series servo motors. The servo motor is controlled by the servo drive unit, which sends commands and receives feedback from the CNC position control circuit.

These servo motors provide the following features:

- Excellent acceleration characteristics due to reduced rotor inertia.
- Waterproofing via water proof connectors and Fanuc's unique stator seal design.
- Smooth rotation via unique magnetic pole shape to minimize torque ripple.
- Precise positioning by an absolute, high-resolution, position coder.

X and Y Motors The X and Y motors are α22/3000 Models, type A06B-0148-B075, equipped with straight shafts and αA64 Model high-resolution position coders. These are 4.4 kW (5.9 hp), 3000 1/min. (rpm) motors.

Z Motor The Z motor is a α30/3000 Model, type A06B-0153-B175, equipped with a straight shaft, an αA64 Model high-resolution position coder, and an internal brake. This is a 4.8 kW (6.4 hp), 3000 1/min. (rpm) motor, with a 35 Nm (25.8 ft·lb) torque brake.

Table 7-1 lists additional motor specifications.

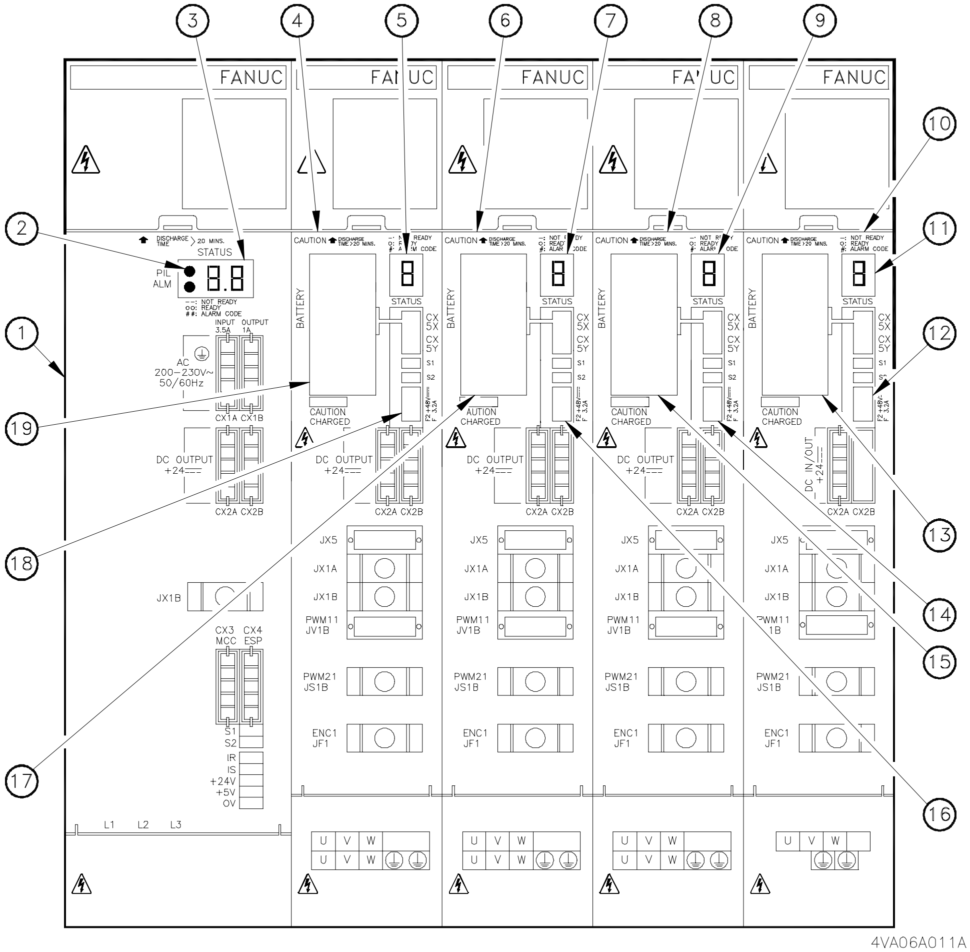
TABLE 7-1 AXIS MOTOR SPECIFICATIONS

Item	Motor Model	
	α22/3000	α30/3000
Output	4.4 kW (5.9 hp)	4.8 kW (6.4 hp)
Rated Torque at Stall	22 Nm (1.2 ft·lb)	30 Nm (2.1 ft·lb)
Rated Output Speed	3000 1/min. (rpm)	3000 1/min. (rpm)
Maximum Theoretical Torque	130 Nm (95.8 ft·lb)	200 Nm (147.4 ft·lb)
Rotor Inertia	0.012 kg m^2 (0.63 ft·lb)	0.017 kg m^2 (0.94 ft·lb)
Max. Theoretical Acceleration	11000 rad/s^2	12000 rad/s^2
Weight	29 kg (64 lb)	41 kg (90 lb)

1 Actual Maximum Torque is restricted by the Servo Amplifier - Current Limit values.

NOTES:

SKETCHES:



Legend[

[1]	Power Supply Module	[11]	Status Display
[2]	PIL and ALM LED'S	[12]	Fuse
[3]	Status And Alarm Display	[13]	Battery Backup
[4]	X Amplifier Module	[14]	Fuse
[5]	Status Display	[15]	Battery Backup
[6]	Y Amplifier Module	[16]	Fuse
[7]	Status Display	[17]	Battery Backup
[8]	Z Amplifier Module	[18]	Fuse
[9]	Status Display	[19]	Battery Backup
[10]	ATC Amplifier Module		

FIGURE 7-5 SERVO DRIVE UNIT

7.4.2 Electronic Assembly

The main electronic assembly for the V55 servo system is the servo drive unit (Figure 7-5). This unit includes: one PSM (Power Supply Module), three SVM (Servo Amplifier Modules), one for each axis, and a fourth amplifier module for the ATC magazine. The servo drive unit is located in the MTC (Machine Tool Cabinet).]

7.4.2.1 Power Supply Module (PSM)

The Fanuc PSM supplies power to the spindle and servo amplifier modules. The PSM converts 3-phase AC input voltage to DC voltage.

The Fanuc PSM is a:

Model No. PSM-26, Type A06B-6082-H126

The PSM contains its own protection and error detection functions (Figure 7-6). Two 7-segment displays, on the front of the PSM, display an alarm number in the event of a PSM fault.

See chapter 5 for details on the self-diagnostic displays and appendix A for a description of PSM alarms.

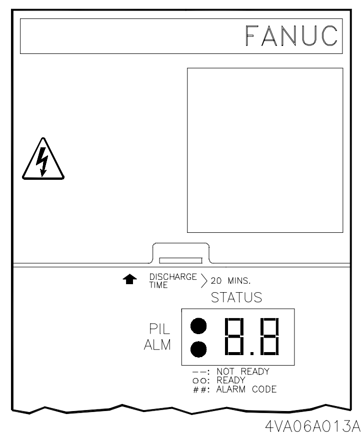


FIGURE 7-6 PSM SELF-DIAGNOSTIC DISPLAY

Table 7-2 lists the general specifications for the PSM-26 power supply.

TABLE 7-2 PSM-26 SPECIFICATIONS

Item		Specification
	Control Power	AC200V/230V - +10%, -15% Single-Phase - 50/60Hz ± 1Hz
Power Capacity	Main Circuit	37kVa
	Control Power	0.5kVa
Rated Output		26kW
Maximum Output		40KW
Control Method		Regenerative Control (Power Supply Regeneration)
Ambient Temperature		0° to 55° C (32° to 130° F)

7.4.2.2 Servo Amplifier Modules – SVM

Each axis (X, Y, and Z) is equipped with its own Fanuc SVM to control the speed of its AC servo motor by using a PWM (Pulse Width Modulator) inverter to regulate the DC power converted by the PSM.

The Fanuc Servo Amplifier Module is:

Model No. SVM1-130, Type A06B-6079-H106

The SVM's contain their own protection and error detection functions (Figure 7-7). A 7-segment display, on the front of each SVM, display an alarm number in the event of a SVM fault.

See chapter 5 for details on the self-diagnostic displays and appendix A for a description of PSM alarms.

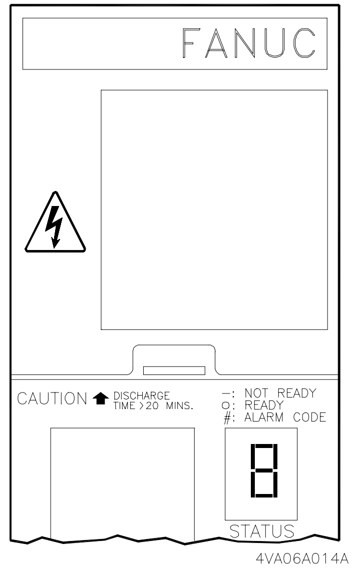


FIGURE 7-7 SVM SELF-DIAGNOSTIC DISPLAY

Table 7-3 lists the general specifications for the SVM1-130.

TABLE 7-3 SVM1-130 SPECIFICATIONS

Item	Specification
Rated Output Current	51.0A rms
Nominal Current Limit	130A (peak)
Main Circuit Control Method	Sine-wave PWM Control with Transistor (IGBT) Bridge
Feedback Method	Absolute, High-Resolution Position Coder
Alarm & Protection Functions	Low voltage alarm for control power Low voltage alarm for DC Link Overcurrent alarm IPM (Intelligent Power Module) alarm Fan alarm
Motor Application	α20/3000 and α30/3000
Ambient Temperature	0° C to 55° C (32° F to 130° F)

1. Rated output is guaranteed only at rated input voltage. If input voltage varies, rated output may not be obtained even when within the allowable range.
2. Current limit (peak value) is a standard value. It varies ±10% depending on circuit constraints.

7.4.2.3 Sliding Member Components

Axis design requires axis components that move or slide. On the V55 these sliding members consist of the castings and related components that make up the saddle, table, and ram. These members form the X, Y, and Z axes respectively.

The V55 uses LM (Linear Motion) guide systems specifically designed for machine tool applications. LM guides provide excellent damping characteristics and high strength when subjected to shocks and vibration.

LM guides consists of; a guide rail [4], guide block [3], end caps [2], seals [1], re-circulating balls [5], and a grease fitting [6].

- On the V55, the guide blocks are plumbed for central lubrication and do not have grease fittings.

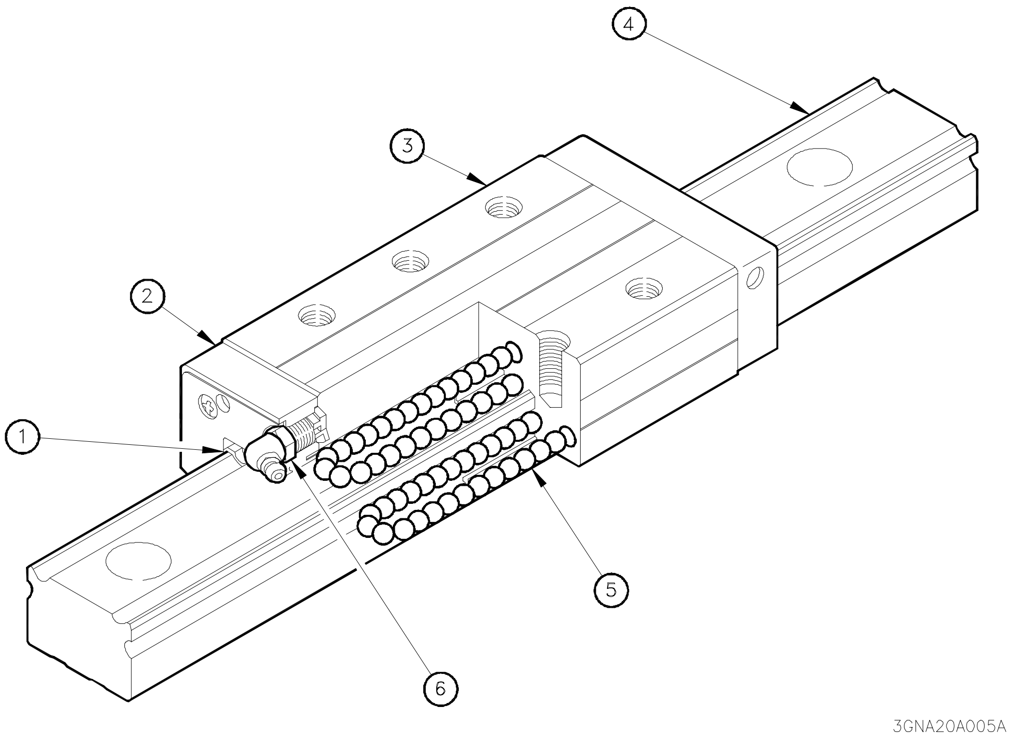


FIGURE 7-8 LM GUIDE CONSTRUCTION

7.5 Axis Construction

Figure 7-9 shows the construction of a typical drive mechanism. On all axes, the ball screw is coupled directly to the servo motor output shaft [1] by an in-line coupling [2]. The coupling [2] is fixed to the motor output shaft [1] and the end of the ball screw [8] by a set of tapered clamp (SPANN) rings and clamp ring retainers. (See section 7.5.1 for detail.)

Linear axis motion is provided by the ball nut [7] attached to the sliding member [4]. Rotation of the servo motor turns the balls screw [8], moving ball nut [7] and sliding member [4]. Positive Stops [5] and [9] are placed at each end of the ball screw [8] to prevent the axis from exceeding its allowed range of movement (travel).

The ball screw [8] is supported by TAC bearings; three at the motor end [3] and two at the outboard end [6]. When the ball screws are installed they are pre-tensioned (stretched), to minimize positioning deviation. (See section 7.6.4 for detail).

All V55 ball screws are core cooled by temperature controlled Makino Spindle Lubricant supplied by the oil controller. Oil is pumped into the outboard end of the ball screw and exits the motor end. This oil also lubricates the TAC bearings at both ends of the ball screw.

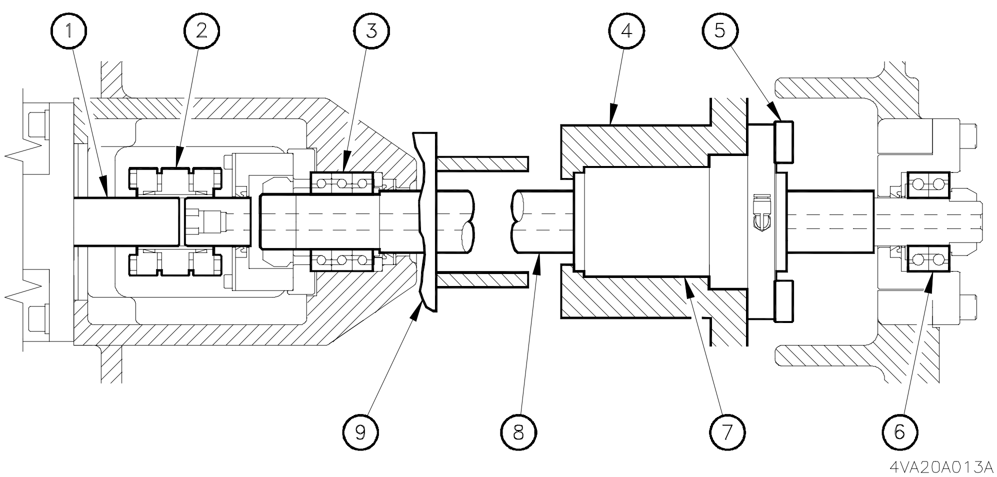


FIGURE 7-9 AXIS DRIVE COMPONENTS

7.5.1 Axes Couplings

This procedure is for mounting the coupling components to the motor output shaft and ball screw.

SPANN Rings

SPANN ring couplings eliminate hard-keyed shafts and allow slippage at the coupling to minimize machine and drive component damage in the event of a “crash”. This slippage may change the ball screw-to-motor pulse coder relationship, changing the location of the axis reference point, which can be corrected using the CNC Grid Shift parameter.

- Following this procedure, it will be necessary to check and reset the axis reference point, using the CNC Grid Shift parameters.

To assemble coupling (Figure 7-10) proceed as follows:

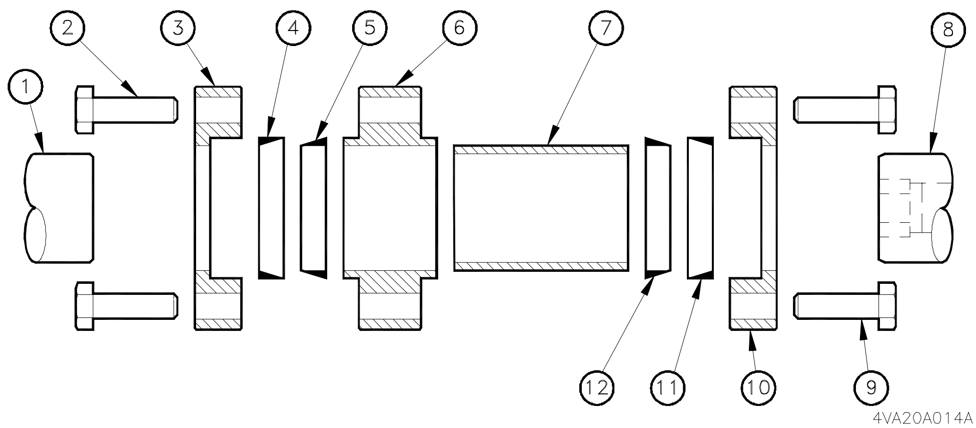


FIGURE 7-10 COUPLING ASSEMBLY

1. Clean and inspect all components (clamp rings, coupling, clamp ring retainer, motor shaft, and ball screw end. Use a stone to remove any nicks or dings, replace components if necessary or if gaulding is seen on clamp rings.
2. Place sleeve [7] into the coupling [6].
3. Install the motor side clamp rings [4] and [5] onto sleeve [7]. Orient and install the “male” ring [5] first and then install the “female” ring [4], as shown.
4. Install the clamp ring retainer [3] using six (M6x25) screws [2]. Tighten the screws just enough to hold the clamp rings captive, but not compressed.
5. Install the ball screw side clamp rings [11] and [12] onto sleeve [7]. Orient and install the “male” ring [12] first and then the “female” ring [11], as shown.

6. Install the clamp ring retainer [10] using six (M6x20) screws [9]. Tighten the screws just enough to hold the clamp rings captive, but not compressed.

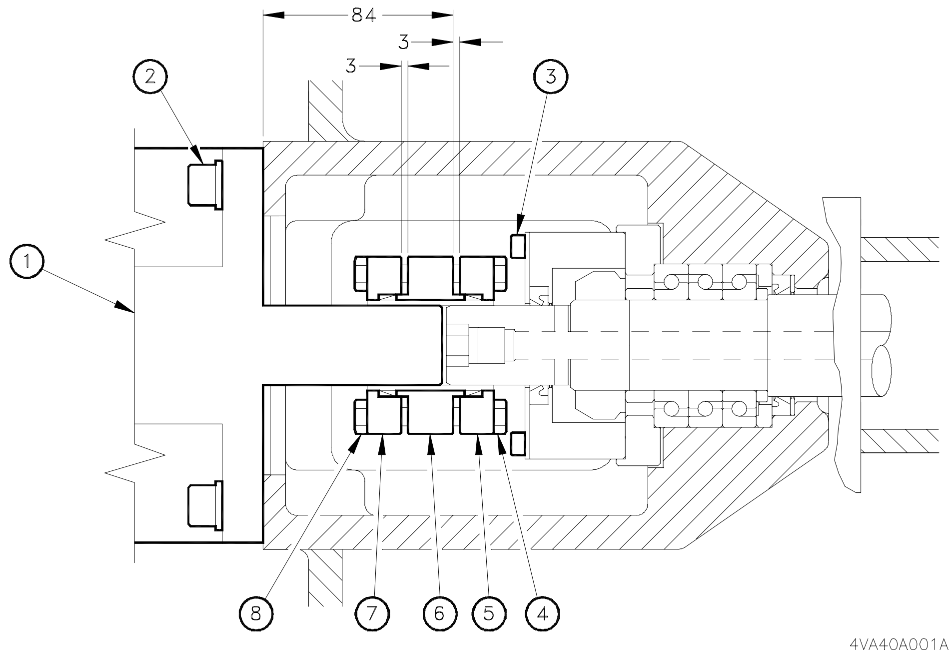


FIGURE 7-11 BALL SCREW-TO-MOTOR COUPLING

7. Install the coupling assembly onto the motor shaft (Figure 7-11).

   A. Position the coupling assembly on the servo motor [1] shaft to place the coupling [6] outer edge 84mm (3.3") from the motor face.

   - The 84mm dimension must be held to properly position the coupling on the motor shaft and avoid coupling retainer screws [4] and seal retainer screws [3] interference.

   B. Remove and re-install the six screws [8], using Loctite 242 on the threads.

   C. Evenly tighten the screws in a cross-over pattern, torque to 18 Nm (13 ft·lb).

   D. Check for an equal and approximate 3.0mm gap, between clamp ring retainer [7] and coupling [6], to ensure the retainer is seated squarely.

   - The 3.0mm gap is not critical. However, an equally spaced gap to ensure the assembly is not “jammed” together, which may result in a binding condition, is important.

WARNING

Coupling Rotation

The following Steps may require turning the machine **ON** and using the axis MPG to rotate the coupling for access to the screws. If this is necessary, ALWAYS turn the HANDLE mode **OFF**, before working in the coupling area, to AVOID accidental coupling rotation.

8. Place the motor/coupling assembly into position on the ball screw and install the four (M12x40) screws and spring washers [2].
   A. Be careful to avoid “cocking” the motor/coupling assembly which could result in damage to the coupling rings or ball screw.
   B. Remove and re-install the six screws [4], using Loctite 242 on the threads.
   C. Evenly tighten the screws in a cross-over pattern, torque to 18 Nm (13 ft·lb).
   D. Check for an equal and approximate 3.0mm gap (Figure 7-11) around the clamp ring retainer [5] and coupling [6], to ensure the retainer is seated squarely.
   - The 3.0mm gap is not critical. However, an equally spaced gap to ensure the assembly is not “jammed” together, which may result in a binding condition, is important.
9. Check and reset the axis reference point.

7.5.2 Z Axis Construction

DANGER

Gravity Axis

The Z axis is a vertical sliding member and must be supported before disconnecting any portion of the drive train. Always place a suitable brace between the ram and table when working on the Z axis drive train. Failure to block the ram may result in the axis moving downward, causing injury or death.

As the gravity axis, the Z axis servo motor is equipped with a DC brake to prevent the axis from coasting down, when power is Off. The brake releases when the servo drive is READY and engages when the drive is NOT READY.

The Z axis is constructed like X and Y. However, it is very **important** to understand that the Z axis is a gravity axis and will fall if any portion of the drive train is disconnected.

7.6 Ball Screw

A ball screw is mounted on each axis, between and in-line with the LM guides. The ball screw is precision machined and hardened to provide maximum accuracy. A single or double ball nut is mounted on each ball screw, depending on the type of ball screw specification.

The V55 is available with standard specification - 16mm lead ball screws or with optional Die/Mold specification - 8mm lead ball screws. The Standard Specification screws use single ball nuts on each axis and the Die Mold Specification screws have double nuts on each axis.

Double Nut Screws

A double nut screw system consists of two ball nuts with a spacer imparting a preload between the nuts. Each nut is loaded against the screw in opposite directions to minimize the amount of lost motion during change of direction.

7.6.1 Ball Screw Specifications

Table 7-4 lists the specifications for the standard 16mm ball screws and Table 7-5 lists the specification for the Die/Mold 8mm ball screws

TABLE 7-4 STANDARD BALL SCREW SPECIFICATIONS

Item	Axis		
	X	Y	Z
Model Designation	BKN-4516S-14	BKN-4516S-14	BKN-4516S-14
Threaded Shaft OD	45 mm	45 mm	45 mm
Shaft Length	1715 mm	1015 mm	903 mm
Lead	16 mm	16 mm	16 mm
Ball Circle Diameter	46. 5 mm	46. 5 mm	46. 5 mm
Steel Ball Diameter	5.556 mm	5.556 mm	5.556 mm
Number of Circuits x Turns	1 x 2.7	1 x 2.7	1 x 2.7
Pre-load	2.3 kN	2.3 kN	2.3 kN
Pre-Load Method	Tension	Tension	Tension
Lead Error Variation Total	±0.059 mm	±0.035 mm	±0.035 mm

TABLE 7-5 DIE/MOLD BALL SCREW SPECIFICATION

Item	Axis		
	X	Y	Z
Model Designation	BNFN-4508S-7.5	BNFN-4508S-7.5	BNFN-4508HSS-5
Threaded Shaft OD	45 mm	45 mm	45 mm
Shaft Length	1715 mm	1015 mm	903 mm
Lead	8 mm	8 mm	8 mm
Ball Circle Diameter	46. 25 mm	46. 25 mm	46. 25 mm
Steel Ball Diameter	4.763 mm	4.763 mm	4.763 mm
Number of Circuits x Turns	3 x 2.5	3 x 2.5	2 x 2.5
Pre-load	3.45 kN	3.45 kN	1.87 kN
Pre-Load Method	Tension	Tension	Tension
Lead Error Variation Total	+/-0.054 mm	+/-0.035 mm	+/-0.035 mm

7.6.2 Ball Screw/Servo Motor Lubrication and Cooling

A description of the V55 drive train lubrication and cooling follows and includes:

- Ball nut lubrication
- Ball screw cooling
- TAC bearing lubrication
- Servo motor cooling

7.6.2.1 Ball Screw Nut Lubrication

The V55 ball nuts are lubricated from two locations. The Y axis ball nut is lubricated at the front of the table. The X and Z ball nuts are lubricated at the right side of the saddle. See section 7.12.3 (pg 7-78) for details.

7.6.2.2 Ball Screw Cooling

All V55 ball screws are core cooled to minimize the affects of thermal distortion on positioning accuracy. Oil controller pump P4, supplies oil to cool the ball screw and lubricate the TAC bearings continuously when machine power is On (section 7.6.2.3). Cooling oil is supplied as follows:

1. P4 scavenges oil from the oil controller tank through line BL01.
2. P4 pumps oil to outboard each ball screw end through lines BL02X, BL02Y, and BL02Z.
3. Oil flows through the ball screw core to the motor end.
4. At motor end, oil is ported through inner drillings in the side of the ball screw to cool and lubricate the TAC bearings.
5. Oil from the TAC bearings is “teed off” and ported to the servo motors, for cooling.
6. Oil is returned to the tank through lines BL03X, BL03Y, and BL03Z, for the X, Y, and Z axes respectively.

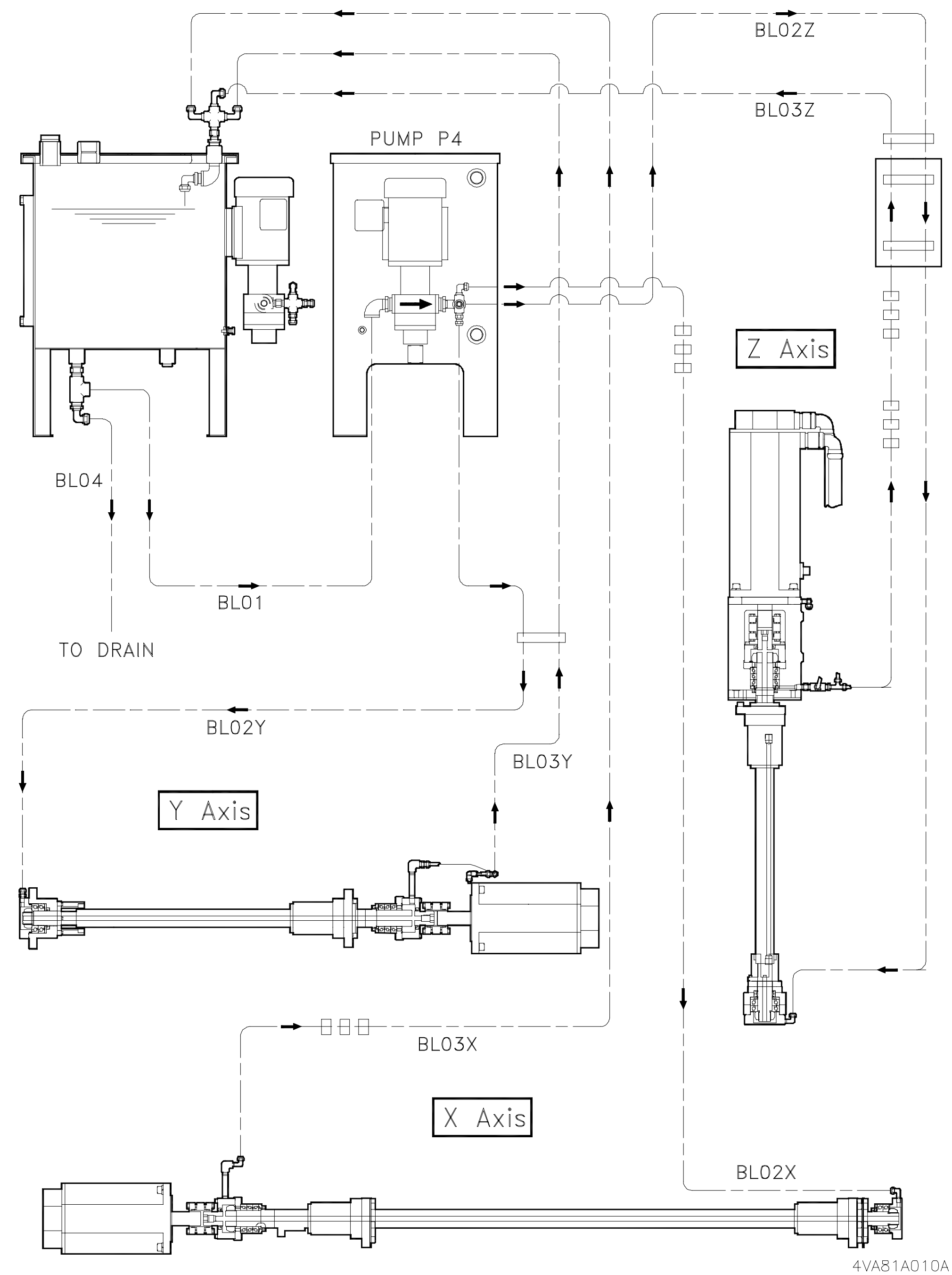


FIGURE 7-12 BALL SCREW COOLING OIL AND TAC BEARING LUBRICATION PIPING

7.6.2.3 Ball Screw TAC Bearing Lubrication

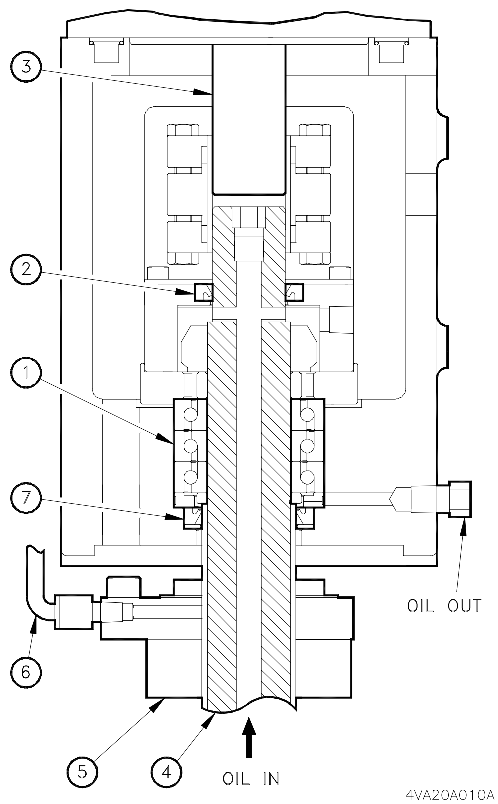
The oil controller supplies Makino Spindle Lubricant to cool and lubricate the TAC bearings (Figure 7-13).

Oil fed to the ball screw core exits through the sides of the ball screw, at the motor end, and flows through the TAC bearing assembly.

After exiting the TAC bearings the oil is piped to the servo motors (section 7.6.2.4) and then returned to tank.

All TAC bearing areas are sealed to contain the oil.

- When replacing a ball screw or bearings, properly orient these seals to ensure oil containment.



Legend

[1]	Tac Bearings	[5]	Ball Nut
[2]	Seal	[6]	Grease Line
[3]	Motor Shaft	[7]	Seal
[4]	Ball Screw		

FIGURE 7-13 TAC BEARING LUBRICATION DETAIL

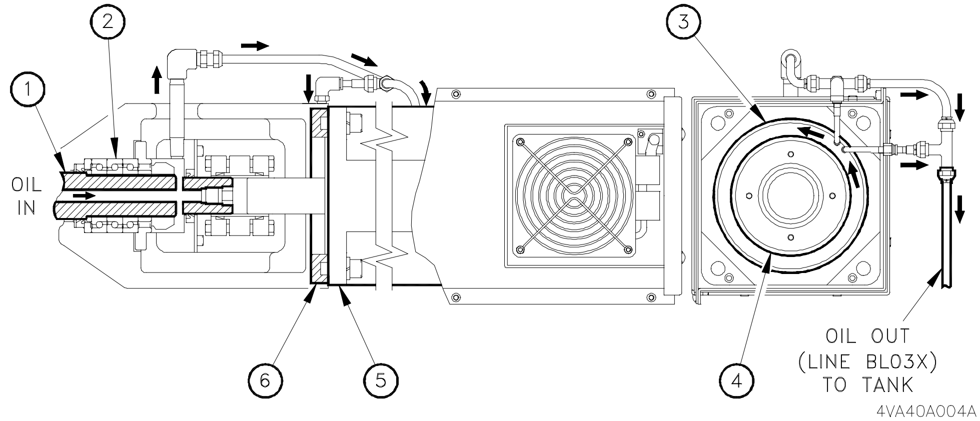
NOTES:

SKETCHES:

7.6.2.4 Servo Motor Cooling

The X, Y, and Z servo motors are cooled by oil from the ball screw TAC bearings. Oil is fed to distribution plates between the servo motors and bearing housings. Oil flows through the plates cooling the motors back to the distribution plates and returned to tank.

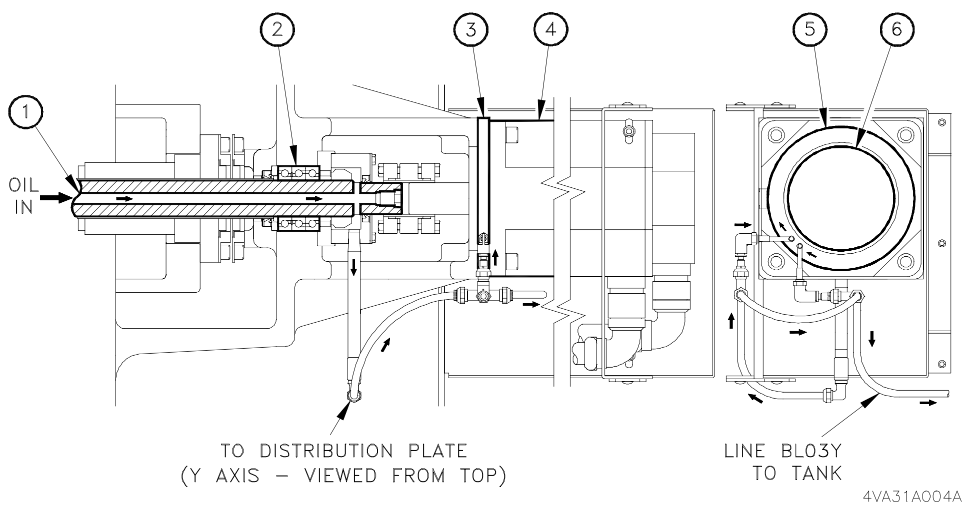
The X axis motor also has a cooling fan.



Legend

[1]	Ball Screw	[3]	S150 O-ring	[5]	Servo Motor
[2]	Tac Bearings	[4]	S125 O-ring	[6]	Distribution Plate

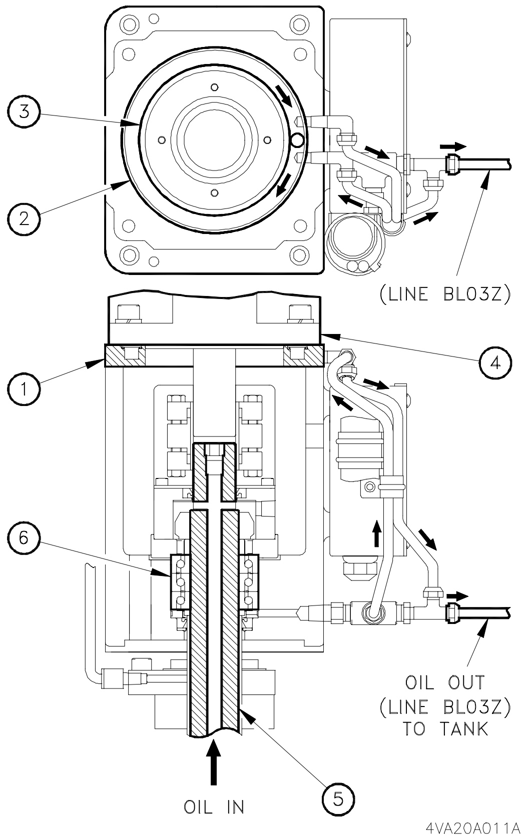
FIGURE 7-14 X SERVO MOTOR COOLING PIPING



Legend

[1]	Ball Screw	[3]	Distribution Plate	[5]	G150 O-ring
[2]	Tac Bearings	[4]	Servo Motor	[6]	G125 O-ring

FIGURE 7-15 Y SERVO MOTOR COOLING PIPING



Legend

[1]	Distribution Plate
[2]	S150 O-ring
[3]	S120 O-ring
[4]	Servo Motor
[5]	Ball Screw
[6]	Tac Bearings

FIGURE 7-16 Z SERVO MOTOR COOLING PIPING

Servo Motor Installation

When installing a servo motor, the distribution plate must be properly oriented with the two O-rings installed, to distribute and contain the oil

7.6.3 Ball Screw Mounting

When mounting a ball screw, ensure proper orientation of the TAC bearings (at both ends of the screw) and the installation of seals and O-rings.

Service Tips

1. Proper bearing orientation sets the correct bearing pre-load. Improper bearing orientation leads to excessive backlash and premature bearing failure.
2. Proper seal orientation is essential to contain the cooling and lubrication oil.

This procedure is for installation of ball screw mounting components, at both ends of the screw.

Mounting motor end components (Figure 7-17):

1. Place the ball screw into position in both the servo motor and outboard end support housings.
2. For the X and Y axes, shim the ball screw with wood blocks at both ends to obtain an approximate alignment within both housings.
3. Temporarily install one TAC bearing on ball screw outboard end. This supports and aligns the screw while installing the motor end.
4. At the motor end, install the rotary seal collar [13].
5. Install rotary seal [14], orient the seal as shown.
6. Install inner race collar [12], onto ball screw.
7. Install outer race collar [11], into housing.
8. Install three TAC bearings [10], orient bearings as shown.
9. Install inner race collar [16], onto ball screw.
10. Place O-ring [15] over outer race and install the bearing case [8].
11. Install the four (M6x20) screws [9] and torque to 18 Nm (13 ft·lb) using a cross-over pattern. This step seats the outer races.
12. Install and fully tighten lock nut [6], to seat the inner races. Tighten the lock nut set screw to prevent lock nut from backing off.
13. Install O-ring [7] in the face of bearing case [8].
14. Install sealing case [5], four (M6x45) screws.
15. Install rotary seal [3], orient the seal as shown.
16. Install plate [2], four (M6x20) screws.

Mounting outboard end components (Figure 7-17):

1. Remove the TAC bearing (temporarily installed in Step 3 for mounting the motor end components).
2. Install rotary seal [24], orient the seal as shown.
3. Install outer race collar [25], orient the collar as shown.
4. Install TAC bearings [23], orient the bearings as shown.
5. Install lock nut [18].
6. Thoroughly tighten the lock nut to seat the bearings, back it off and run it in until it just touches the bearings.
7. Pre-tension the ball screw, see section 7.6.4.
8. After pre-tensioning the ball screw, complete the final installation steps listed below.

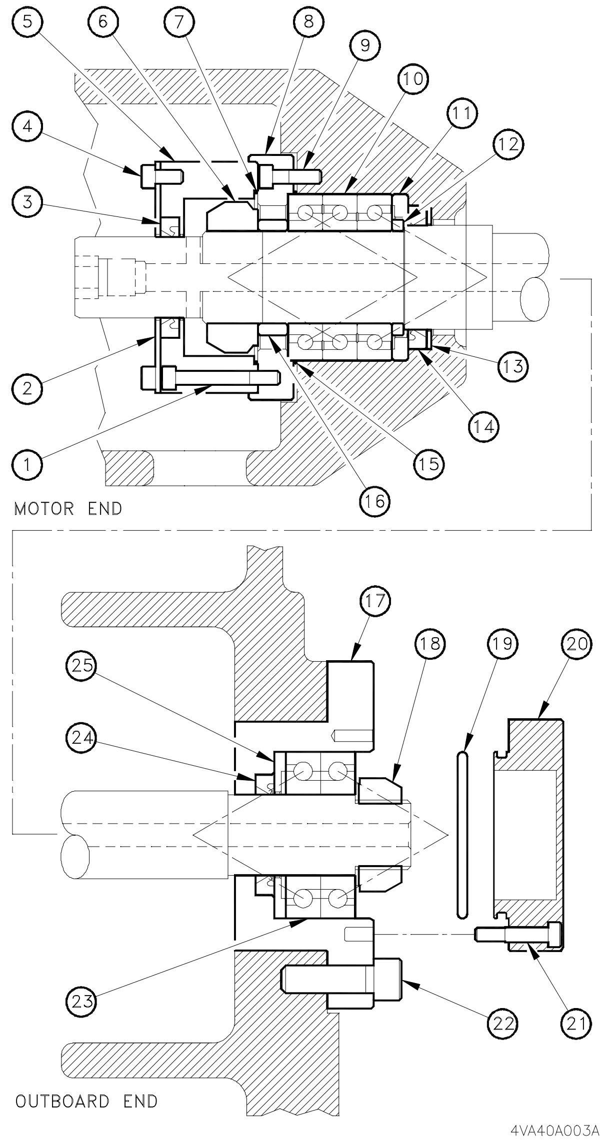


FIGURE 7-17 INSTALLATION OF BALL SCREW MOUNTING COMPONENTS

Final installation steps:

1. Attach the ball screw nut to the sliding member.
2. Install the servo motor.
   Make sure the distribution plate and O-rings are properly installed.
3. Install the sealing case [20], O-ring [19], and four (M6x25) screws [21], at the outboard end of the ball screw.
4. If necessary, connect the oil line in the end of the sealing case.

7.6.4 Ball Screw Pre-Tension

The X, Y, and Z ball screws are pre-tensioned (stretched) at installation to minimize changes in axis positioning due to thermal growth of the screw. When an axis moves, heat is generated by the recirculating balls in the nut. The screw is subject to thermal growth by the coefficient of thermal expansion (12 x 10-6/C°).

The screw shaft grows 0.012/1000mm (0.00047/39.37") with a temperature rise of 1° C (1.8° F).

The average ball screw temperature rise is 3 to 4° C (5.4 to 7.2° F). Pre-tensioning places a cold screw under tension. The tension decreases or normalizes, as the ball screw expands toward its normal operating temperature, minimizing axis position deviation.

TABLE 7-6 BALL SCREW PRETENSION AMOUNTS

Axis	X = B-A (MM)	X = B-A (INCH)
X	0.054	0.0021
Y	0.035	0.0014
Z	0.035	0.0014

Table 7-6 lists the pre-tension amounts for each axis.

7.6.4.1 Pre-Tension Procedure

If the ball screw has been released or removed for any reason, follow this procedure to pre-tension the ball screw.

Before mounting the X, Y, or Z axis servo motor:

1. Mount the ball screw [1], see section 7.6.3 (pg 7-26).
2. Tighten the outboard end lock nut [2], to seat the bearings.
3. Loosen lock nut [2] and run it back in to touch the bearings.
4. Place an indicator [3] and [4] on each end of the ball screw and set the indicator to zero. (Be sure to load the indicator at about mid-range.)
5. Tighten lock nut [2] until the difference in the reading on indicator **B** and indicator **A** equals the pre-tension amount for the axis, Table 7-6.
6. Mount the servo motor, see section 7.5.1 (pg 7-15).
7. Check the axis reference points and reset, if necessary.

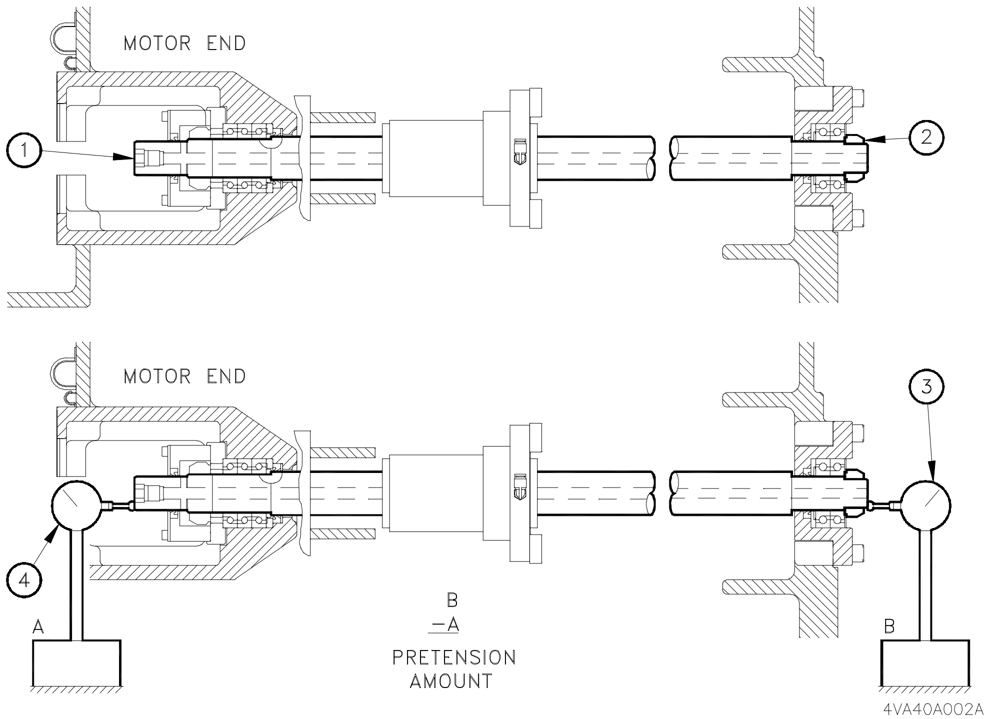


FIGURE 7-18 BALL SCREW PRE-TENSION PROCEDURE

7.7 LM (Linear Motion) Guide Ways

The V55 uses LM (Linear Motion) guides on all three axes (X, Y, and Z). These LM guides are specifically design for machine tool applications and provide excellent damping characteristics and high strength when subjected to shocks and vibration.

The X and Y axes LM guides are THK Model NR45, and the Z axis guides are THK Model SNS45. Both models are similar in design with the exception that the SNS45 Model uses a retainer to separate the re-circulating balls for enhanced lubrication and reduced friction (no ball-to-ball contact). This SNS45 design also:

- Reduces running noise levels
- Improves bearing life because of non ball-to-ball contact
- Reduces drive torque requirements, due to less friction, necessary to achieve high acceleration/deceleration performance characteristics.

Figure 7-19 shows the basic components of an LM guide. This system consists of a guide rail [4], guide block [3], end caps [2], seals [1], re-circulating balls [5], and a grease fitting [6].

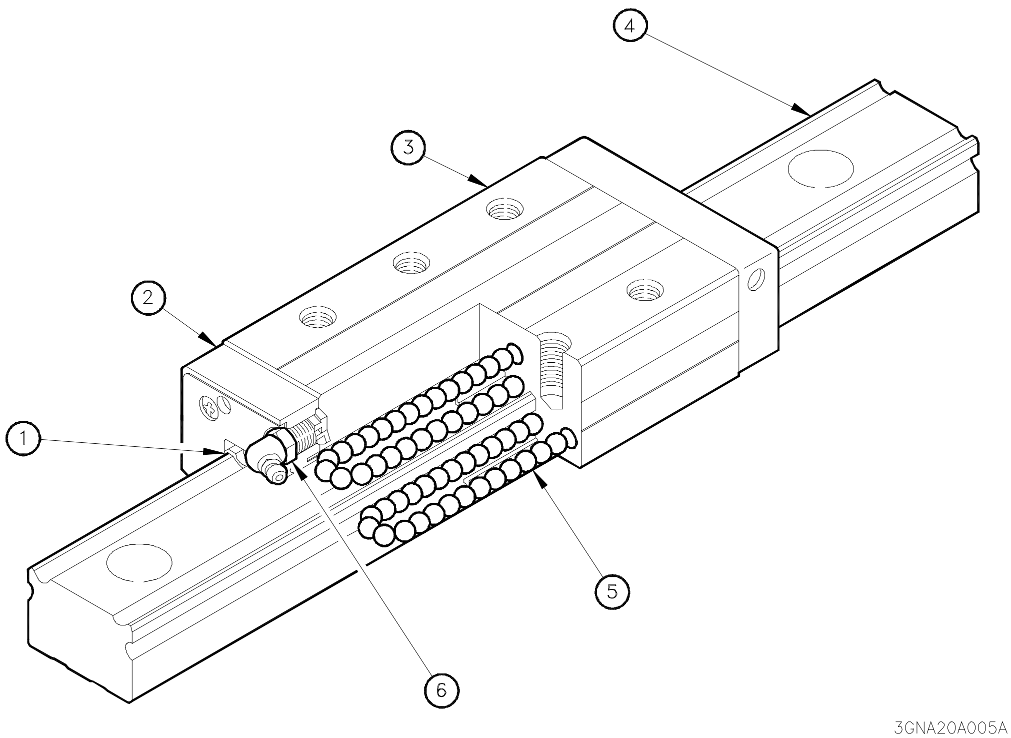


FIGURE 7-19 LM GUIDE CONSTRUCTION

7.7.1 LM Guide Specifications

Table 7-7 lists the LM guide specification by axis.

TABLE 7-7 LM GUIDE SPECIFICATIONS

Item	X Axis	Y Axis	Z Axis
Model Number	NR45	NR45	SNS45
Block Type	Flange Type - Ultra Heavy Load w/ Tapped Holes	Flange Type - Ultra Heavy Load w/ Tapped Holes	Flange Type - Ultra Heavy Load w/ Tapped Holes
No. of Blocks per Rail	2	2	3
Guide Block Seals [1]	E, S, I	E, S, I	E, S, I
Preload	-10 ~ -15 Nm	-10 ~ -15 Nm	-10 ~ -15 Nm
Rail Length (mm)	990	1935	1164
Accuracy Grade	Precision	Precision	Precision
[1] LM guide block seals are denoted as: E = End, S = Side, I = Inner			

7.7.2 LM Guide Lubrication

The V55 LM guide systems are lubricated from distribution blocks at two locations. Y axis guides are lubricated at grease fittings on the front of the table. X and Z axis guides are lubricated at grease fittings on the right side of the saddle.

See section 7.12.3 (pg 7-78) for details of location and procedures.

7.7.3 LM Guide Installation

All axes have two guide rails. The X and Y axes have two guide blocks per rail and the Z axis has three guide blocks per rail. The mounting characteristic for each axis is defined below.

- The X axis rails are stationary mounted to the top of the column and the blocks are mounted to the saddle.
- The Y axis rails are mounted to the bed and the blocks are mounted to the table.
- The Z axis rails are mounted to the front of the saddle and the blocks are mounted to the ram.

Each axis contains a “datum” and a “subsidiary”. The datum rail is aligned to ball screw centerline and the subsidiary rail aligned to the datum rail.

7.7.4 LM Guide Replacement

Makino uses “Precision Grade” guides which permits individual guide replacement (rather than sets). Also, the guides contain end, side, and inner seals to prevent contamination of the re-circulating balls.

Damage to the guide rails and blocks may occur in the event of a machine wreck. Makino recommends replacing the guide rail and block assembly if either component is damaged. Rail damage may not be apparent to the naked eye.

Guide Rail Replacement

Guide rail installation and replacement should be performed only be qualified personnel, since the installation process sets the proper preload for the guide rail blocks.

7.8 Axis Limit Switches

Each axis is equipped with one limit switch for Deceleration (DEC) and one for over travel (OT2). These limit switches are plunger type mechanisms, actuated by dogs mounted parallel to the axes travel and in-line with the switches.

The limit switch device name, signal name and PMC address for each axis, are presented in Table 7-8.

TABLE 7-8 AXIS LIMIT SWITCH DETAIL

Axis	Item	Device Name	Signal Name	Address
X	OT2 - (Hard over travel LS) DEC - (Deceleration LS)	LS31 (ESP X) LS30 (DEC X)	OT2X *DECX	X10.0 X09.0
Y	OT2 - (Hard over travel LS) DEC - (Deceleration LS)	LS21 (ESP Y) LS20 (DEC Y)	OT2Y *DECY	X10.1 X09.1
Z	OT2 - (Hard over travel LS) DEC - (Deceleration LS)	LS41 (ESP Z) LS40 (DEC Z)	OT2Z *DECZ	X10.2 X09.2

[1] An asterisk (*) preceding a PMC signal name, denotes the device is wired "normally closed"

7.8.1 Deceleration (DEC) Limit Switches

Each axis is equipped with a DEC (Deceleration) switch. During a reference return (machine alignment) operation, actuating a DEC switch changes the reference traverse rate from 4000mm/min. to the "reference slow down" rate. This rate is then maintained until the reference operation is completed.

The deceleration switch is set on the minus side of the axis "zero" or reference point, see section 7.8.5.4 (pg 7-44) for DEC principle of operation.

- These switches are wired "normally closed". This fail safe forces the machine tool to default to a DEC condition, in the event of a circuit failure.

7.8.2 Hard Over Travel (OT2) Limit Switches

Each axis is equipped with one over travel switch and a dog at each end of the axis stroke. These switches are used to protect the machine axis from being over traveled, prior to a reference return operation. OT2 is a hard limit established by the dog. When OT2 is activated, an E-Stop condition is generated dropping out all servo drives to halt axis motion. As with any E-Stop condition, it is necessary to reference return all axes, before resuming automatic cycle.

- The OT2 switches are wired “normally closed”. This fail safe forces the machine tool to default to an OT2 condition in the event of a circuit failure.

7.8.3 Axis Over Travel

There are three over travel stages designed into the machine; OT1, OT2 and the positive stop. These over travel protections are to prevent or reduce machine damage if an axis is run beyond its designed travel limits.

7.8.3.1 OT1 - Soft Over Travel

OT1 or Soft over travel limit is established by the programmable travel limit of each axis. This travel limit is defined by CNC parameter settings. OT1 over travel limits become effective, after a reference return operation.

- OT1 limits are set inside the boundaries established by the OT2-Hard over travel limits, to prevent an axis from tripping the OT2 switch, after the machine has been referenced.
- Activating OT1 does not generate an E-Stop condition. Only the affected axis is stopped, to prevent positioning. Therefore axis position and machine alignment is retained.
- See section 7.8.4 for detail on OT1 recovery.

7.8.3.2 OT2 - Hard Over Travel

OT2 or Hard over travel is set by the trip dogs along the axis. When these dogs contact the OT2 limit switch, the machine enters an E-Stop condition, halting all axis movement and other machine functions immediately.

- OT2 is always active, although OT1 typically prevents OT2 conditions after machine reference.
- Activating OT2 generates an E-Stop condition, requiring manual reference return, after recovery.
- See section 7.8.4 for detail on OT2 recovery.

7.8.3.3 Positive Stop

Each axis is equipped with a mechanical positive stop at each end of the stroke. These stops provide a fail-safe in the event that OT1 and OT2 fail.

- After hitting a positive stop, try to recover using the OT2 recovery method and closely inspect all axis drive components for damage, before resuming machining.

7.8.4 Over Travel Recovery

To recover from an OT1 Soft Over Travel:

If the axis in OT1 is not apparent, view the CNC ALARM screen. One of the messages in Table 7-9 is displayed, indicating the axis and direction of over travel.

TABLE 7-9 OT1 ALARM MESSAGES

500 OVER TRAVEL : + X	501 OVER TRAVEL : – X
500 OVER TRAVEL : + Y	501 OVER TRAVEL : – Y
500 OVER TRAVEL : + Z	501 OVER TRAVEL : – Z

1. Determine which axis is over traveled.
2. Select a Manual mode, and move the axis in the opposite direction of the over travel.
3. Press the [RESET] button.

- Axis position and machine alignment is retained, therefore, it is not necessary to reference the axes.

To Recover From an OT2 Hard Over Travel:

If the axis in OT2 is not apparent, view the Custom - ALARM screen. One of the alarms in Table 7-10 is displayed, indicating the axis and direction of over travel.

TABLE 7-10 OT2 ALARM MESSAGES

Alarm No.	Message
14000	X-AXIS +OT2 ALARM IS BEING GENERATED
14001	X-AXIS -OT2 ALARM IS BEING GENERATED
14002	Y-AXIS +OT2 ALARM IS BEING GENERATED
14003	Y-AXIS -OT2 ALARM IS BEING GENERATED
14004	Z-AXIS +OT2 ALARM IS BEING GENERATED
14005	Z-AXIS -OT2 ALARM IS BEING GENERATED

CAUTION

OT2 Recovery

Always use the MPG (Manual Pulse Generator), instead of the JOG controls, when recovering from an OT2 Hard Over Travel. MPG operation is slower and could prevent damage to the ball screw if the axis is moved in the wrong direction.

1. Determine which axis is over traveled.
2. Select the HANDLE mode.
3. Select the X10 position, on the MPG.
4. Select the axis [X, Y, or Z], on the MPG.
5. Press and hold the [OT RELEASE] button for three seconds, then perform Step 6 while holding the button.
6. Using the MPG, move the over traveled axis in the opposite direction of the Over Travel.
7. Press the [RESET] button, to clear the OT2 alarm.
8. Perform a reference return (machine alignment) operation, for all axes.

7.8.5 Location of Axes Limit Switches

The location of each axis limit switches are described below.

7.8.5.1 X Axis Limit Switch

Figure 7-20 shows the X axis limit switches [1] mounted to the back of the saddle [3]. The switch travels with the X axis. X axis dogs are stationary and mounted on the top of the column [2], just below the saddle, in-line with the switches.

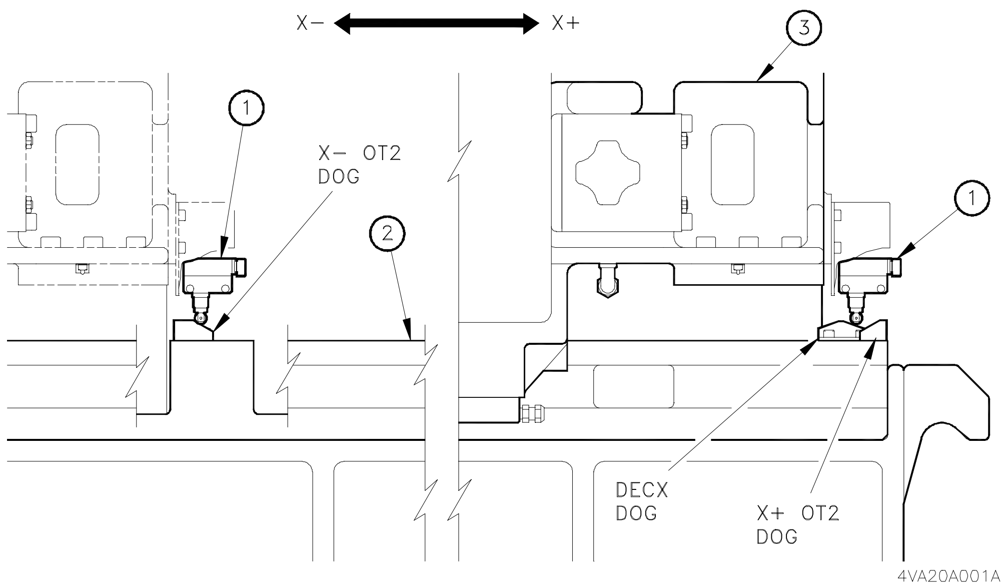


FIGURE 7-20 X AXIS LIMIT SWITCH LAYOUT

7.8.5.2 Y Axis Limit Switch

Figure 7-21 shows the Y axis the limit switches [2] mounted to the table [3]. The switch travels with the Y axis. Y axis dogs are stationary and mounted to the bed [1], in-line with the switches.

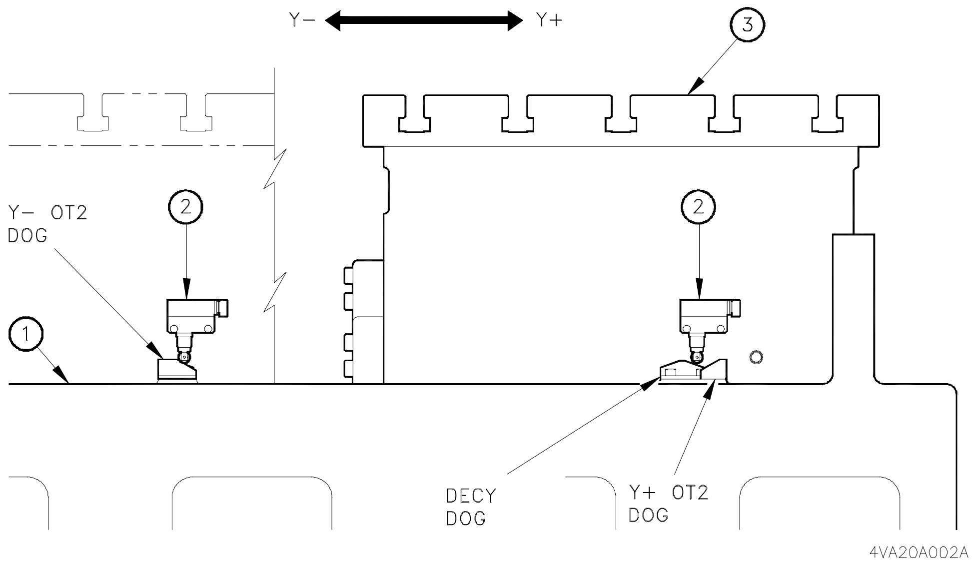


FIGURE 7-21 Y AXIS LIMIT SWITCH LAYOUT

7.8.5.3 Z Axis Limit Switch

Figure 7-22 shows the Z axis limit switches [2]. The switch is stationary and mounted to the right side of the saddle. The Z axis dogs are mounted to the ram [1], in-line with the switches and travel with the Z axis.

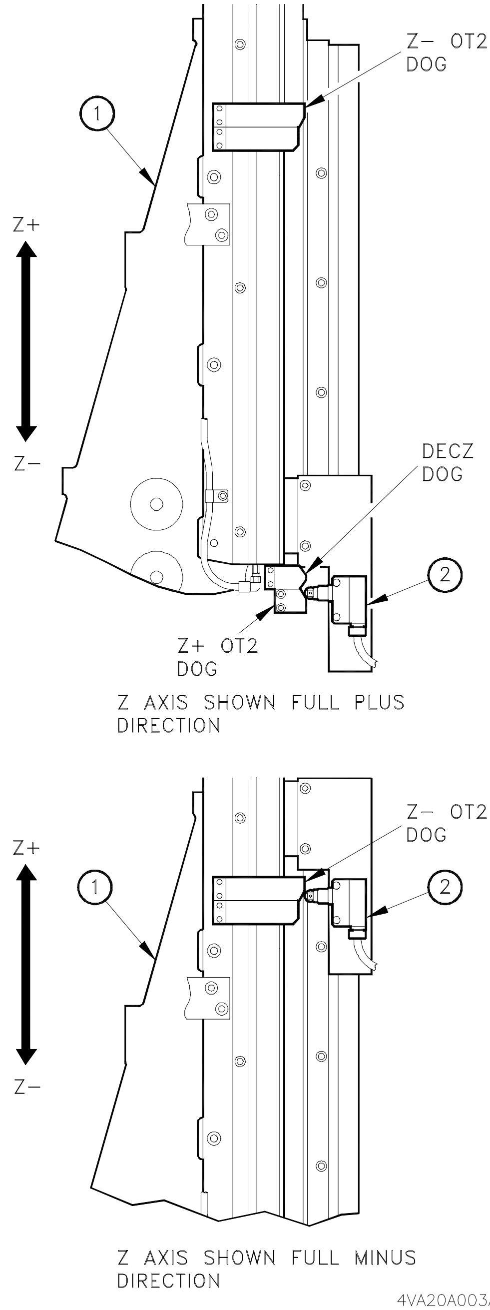


FIGURE 7-22 Z AXIS LIMIT SWITCH LAYOUT

7.8.5.4 Relationship of Limit Switches and Dogs

For proper life and operation it is important to maintain the correct relationship between the limit switches and their actuator dogs.

Switch to dog relationships are set at the factory, during assembly. If the switch or dog must be moved or replaced, during maintenance, ensure the position and relationship of the switch or dog is maintained.

A limit switch is actuated when its plunger contacts a dog. An incorrect plunger to dog setting can result in; the switch not actuating, not actuating at the proper time, or switch damage due to setting too close to the dog.

- Mounting a limit switch too close to its trip dog will cause premature damage and wear to the plunger assembly and switch mechanism.

Setting OT2 Hard Over Travel Limit Switches

Figure 7-23 shows the switch-to-dog relationship for OT2. Switch plunger stroke is 5.2mm (0.204"), with switch actuation occurring after 2.0mm (0.080") of plunger stroke. Set the switch to actuate with 7mm (0.257") of axis travel from the point of actuation to the top of its trip dog.

Setting the switch to more than 7mm (0.257") of axis travel from the point of actuation to the top of its dog could exceed the switch's total plunger stroke of 5.2mm (0.204").

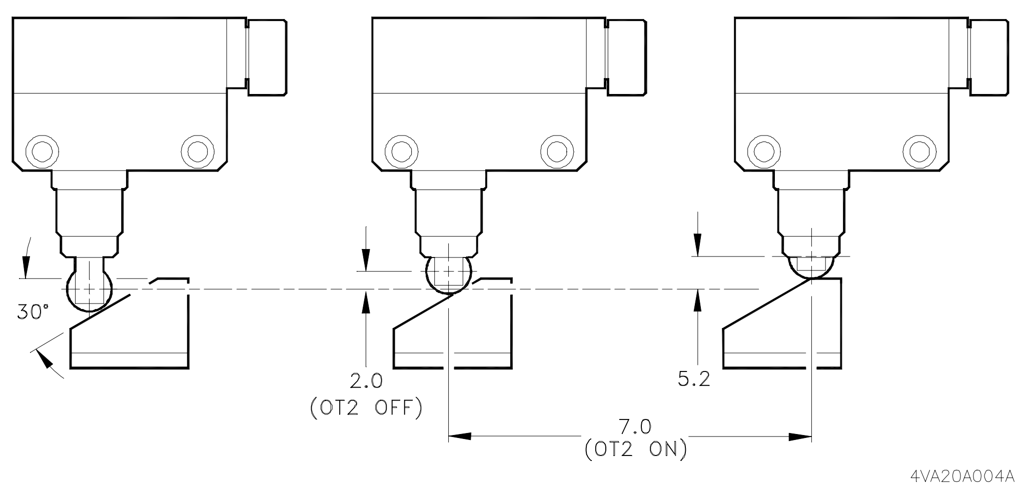


FIGURE 7-23 OT2 LIMIT SWITCH SETTING

Setting DEC Limit Switches

Figure 7-24 shows the DEC limit switch-to-dog relationship. Switch plunger stroke is 5.2mm (0.204"), with switch actuation occurring after 2.0mm (0.080") of plunger stroke. Set the switch to actuate with 4mm (0.157") of axis travel from the actuation point to the top of its trip dog.

Setting the switch so that there is more than 4mm (0.157") of axis travel from the point of actuation to the top of its dog could result in exceeding the switch's total plunger stroke of 5.2mm (0.204")

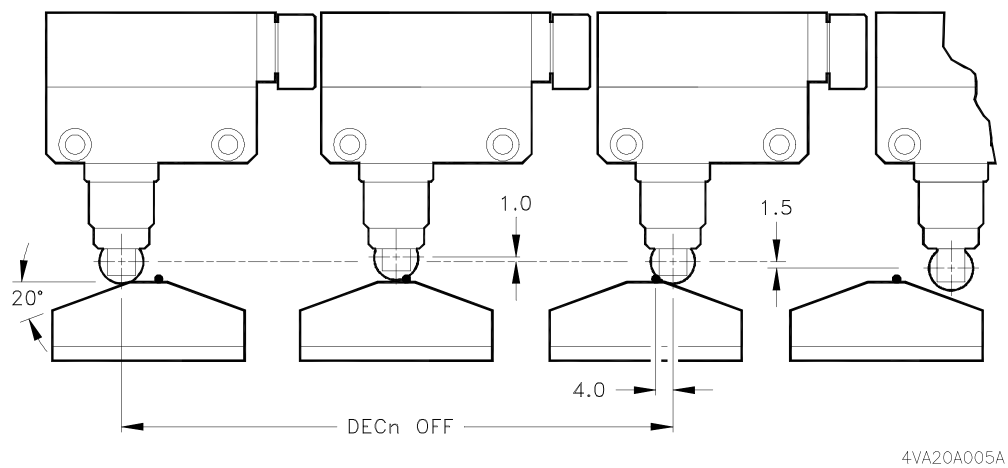


FIGURE 7-24 DEC LIMIT SWITCH SETTING

7.8.6 Machine Range of Movement

The limit switch-to-dog set-up dimensions for the X, Y, and Z axes are shown in Figure 7-25, 7-26, and 7-27, respectively.

- The switch dogs are set in location (at assembly) and there is no reason they should be moved or adjusted.
- Do NOT move the OT2 switch dogs in an attempt to obtain more axis travel. Extending axis travel by moving the OT2 switch dogs will result in the ball screw nut jamming into its mounting bracket.
- During switch replacement, adjust the limit switch not the dogs.

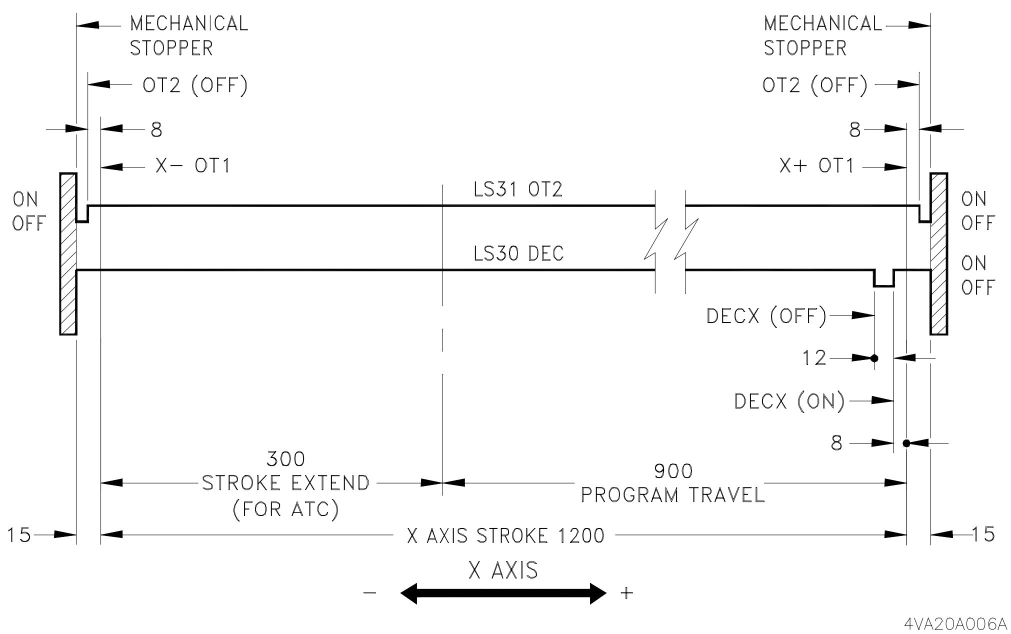


FIGURE 7-25 X AXIS LIMIT SWITCH-TO-DOG SETTINGS

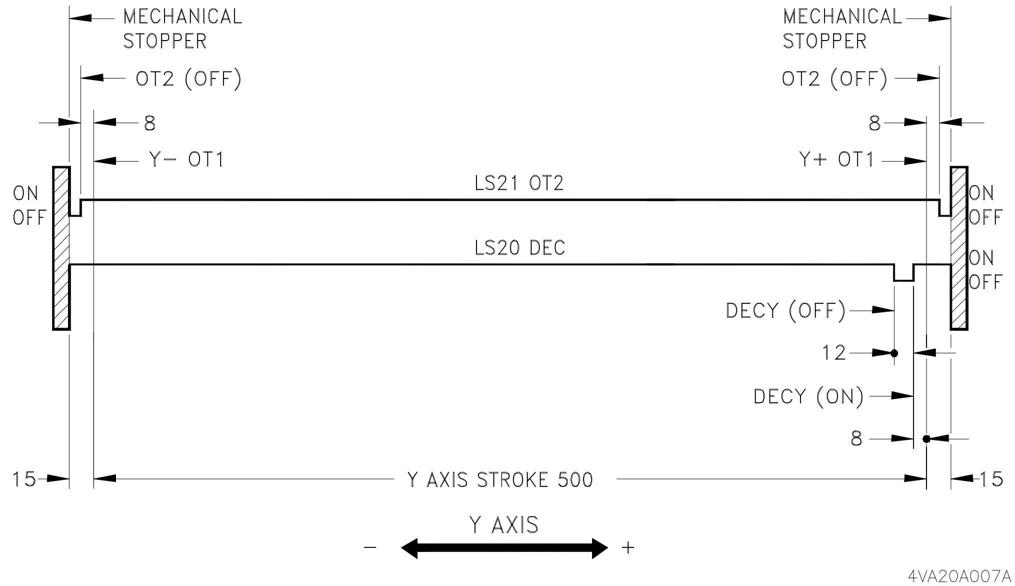


FIGURE 7-26 Y AXIS LIMIT SWITCH-TO-DOG SETTINGS

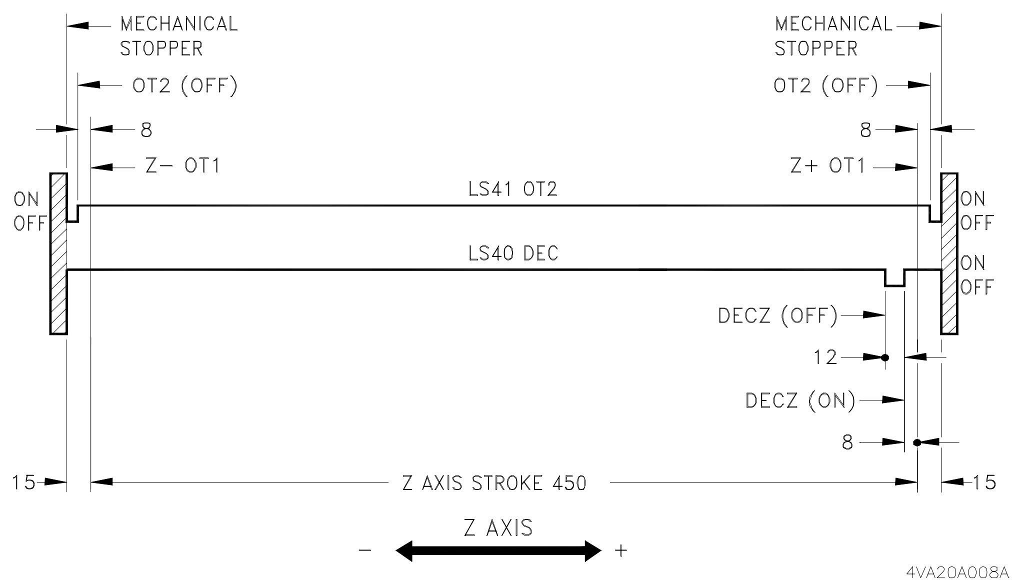


FIGURE 7-27 Z AXIS LIMIT SWITCH-TO-DOG SETTINGS

7.8.7 Machine Reference (Zero) Point

The reference position (zero point) for an axis is detected by the deceleration (*DEC*n*) limit switch, located in the switch package, for each axis. *DEC*n* = the deceleration (DEC) switch, with *n* representing any axis (X, Y, or Z). See Table 7-11 for *DEC limit switch device names, PMC signal names, and address.

*DEC*n* switch operation is the same for all axes.

- *DEC*n* switches are wired “normally closed” condition, Indicated by an asterisk (*).
- The axes are set by parameter to [REFERENCE] from the minus (–) to the plus (+) direction.
- All axes reference points are located at the plus (+) end of axis stroke.

TABLE 7-11 DEC LIMIT SWITCH DETAIL

Axis	Item	Device Name	Signal Name	Address
X	DEC - (Deceleration LS)	LS30 (DEC X)	*DECX	X09.0
Y	DEC - (Deceleration LS)	LS20 (DEC Y)	*DECY	X09.1
Z	DEC - (Deceleration LS)	LS40 (DEC Z)	*DECZ	X09.2

7.8.7.1 Principle of Operation

When [REFERENCE] mode is active and an axis is moved (at the preset 4000mm/min. rate) in the plus (+) direction, toward its zero point, the DEC*n* limit switch is in its normal state (DEC*n* = 1), as shown in Figure 7-28.

As the axis nears its zero point, the DEC*n* switch is actuated by its DEC dog and the switch state changes (DEC*n* = 0). At this point, axis motion decelerates to the reference slow down feedrate and continues moving toward its reference position. The CNC must see the “1 rev pulse marker” pulse while the DECn switch is still on its dog.

Once the 1 rev pulse marker signal is seen, the axis continues to travel in the plus direction until the next pulse coder grid point is reached which is the reference position (machine zero) for the axis. The true reference position may be offset from the grid point by the CNC grid shift parameter 1850, to obtain the full traverse range of the axis.

When the DEC*n* switch falls off the plus (+) end of the DECn dog, the switch returns to its normal state (DEC*n* = 1).

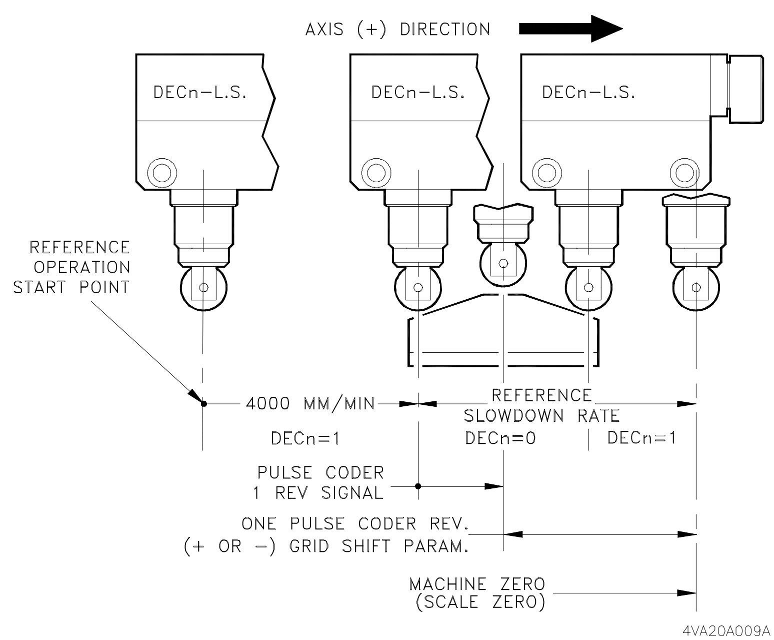


FIGURE 7-28 DEC LIMIT SWITCH OPERATION

7.8.7.2 Establishing Machine Zero Positions

The correct position of machine zero for an axis allows the full axis stroke to be obtained and aligns the axis with other machine components like the ATC, APC, etc. Machine zero is set at the factory and does not change unless the relationship between a ball screw and servo motor changes.

After maintenance functions such as ball screw or servo motor replacement, machine zero for that axis must be reset. Machine wrecks that result in ball screw-to-motor coupling slippage also requires resetting machine zero.

The V55 uses absolute position pulse coders in the servo motors. This means that the machine zero positions are always remembered (stored), even through a machine power Off and On sequence. Even though machine zero is stored, the PMC software requires that all machine axes be aligned by performing a reference operation at machine power On.

When an axis is referenced, it is aligned to pulse coder marker pulse. This is not the “true” machine zero position. Machine zero is typically a position that is shifted from the pulse coder marker pulse by a value set into the Grid Shift parameter 1850. Parameter 1850 provides the ability to shift all machine axes separately.

This section describes how to determine the machine zero position for each axis and the setting values for Grid Shift parameter 1850.

Parameter 1850 Setting Values:

Parameter 1850 setting values are entered as “detection units” in the range of ±99999999. Since the V55 uses metric ball screws, one detection unit is equal to the least input increment of the metric mode.

- One detection unit = 0.001mm

Grid Shift Parameter 1850

The true axis reference position may be adjusted in the plus or minus direction from the grid point by setting Grid Shift parameter 1850. The value set into 1850 tells the CNC to add or subtract the set value from the pulse coder grid point.

The setting value for parameter 1850 is in detect units and is based on the metric system. One detect unit is equal to 0.001 mm. After changing parameter 1850, power must be turned Off and back On, before the parameter change becomes effective.

X Axis Machine Zero

X axis machine zero is set relative to the ATC magazine tool pot centerline (Figure 7-29). The normal X axis stroke (program travel) is 900mm. For X to reach the tool magazine, the “extended stroke” feature is turned On allowing X to travel an additional 300mm.

- The total X stroke is from machine zero to the tool pot centerline 1200mm (program travel + extended stroke).

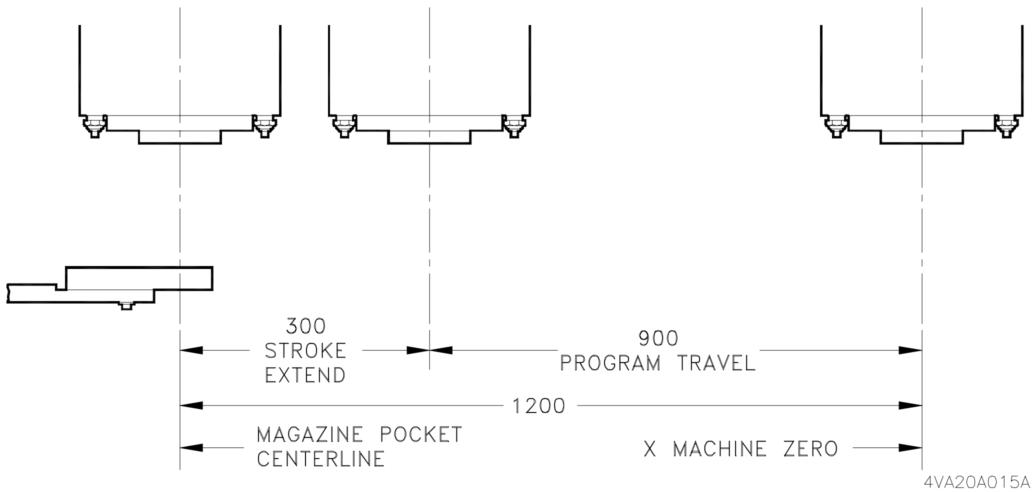


FIGURE 7-29 SETTING X AXIS ZERO

To Check the 1200mm Stroke:

1. Set the X field of parameter 1850 to zero, see section 7.11.
2. Press [POWER OFF], to power down the machine.
3. Press [CONTROL POWER ON], to power up the machine. Perform Step 4 during machine power up.
4. Using the alpha-numeric key pad, simultaneously press [P] and [CAN] keys to cancel the stored machine zero.
5. Set the control to metric (G21).
6. Reference the X axis.
7. Place a tool holder/indicator setup in the spindle.
8. Origin (set to zero) the X axis Relative Coordinate.
9. In the Custom- ATC Maintenance mode:

   A. Open the ATC Shutter.

   B. Turn Extended Stroke On.

10. Place a “test ring” in the pot at the ready position.
    - If a test ring is unavailable, place an end mill holder upside down in the magazine pot.
11. Using the MPG position X to the pot and tram the test ring I.D.
12. Record the X relative coordinate value.
    - This negative value represents the distance X traveled from the current machine zero position to the pot centerline.
13. Determine the Grid Shift parameter setting:

    A. Subtract the value recorded in Step 12 from -1200.000

EXAMPLE: 1. The recorded value is **–1201.234**, Subtract **–1201.234** from **–1200.000**, the result is **+1.234**.

This indicates, X has traveled 1.234mm beyond (plus) the 1200mm total stroke. Therefore the pulse coder grid position must be shifted by 1.234mm in the negative direction.

2. The recorded value is **–1199.567**, subtract –**1199.567** from –**1200.000**, the result is –**0.433**

This indicates, X has traveled 0.433mm short (minus) the 1200mm total stroke. Therefore, the pulse coder grid position must be shifted by 0.433mm in the positive direction.

    B. Divide the result (Step 13 A) by 0.001, to obtain actual setting value.

    C. Enter the result of Step 13 B into the X field of parameter 1850, see section 7.11.

- If the result is a positive, enter a negative value. If the results is a negative, enter a positive value.

Y Axis Machine Zero

Y axis machine zero is set relative to the centerline of the middle T-slot on the table (Figure 7-30). The Y axis stroke (program travel) is 500mm.

- The distance from machine zero to the centerline of the center T-slot should be 250mm.

To Check the 250mm Stroke:

1. Set the Y field of parameter 1850 to zero, see section 7.11.
2. Press [POWER OFF], to power down the machine.
3. Press [CONTROL POWER ON], to power up the machine. Perform Step 4 during machine power up.

4. Using the alpha-numeric key pad, simultaneously press [P] and [CAN] keys to cancel the stored machine zero.
5. Set the control to metric (G21).
6. Reference the Y axis.
7. Place a tool holder/indicator setup in the spindle.
8. Origin (set to zero) the Y axis Relative Coordinate.

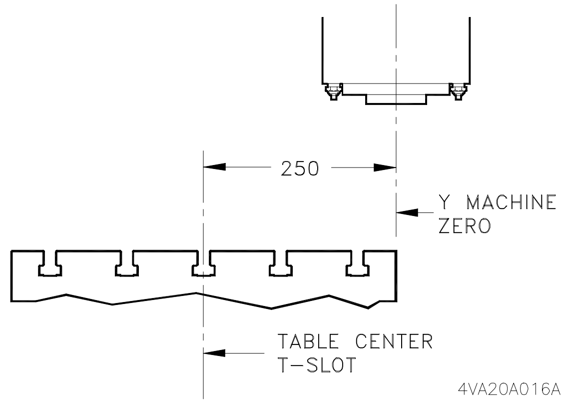


FIGURE 7-30 SETTING Y AXIS ZERO

9. Jog the axes to place the indicator near the center T-slot.
10. Using the MPG for axis movement, sweep the T-slot to find its exact center along the Y axis.
11. Record the Y relative coordinate value.
    - This negative value represents the distance Y traveled from the current machine zero position to the T-slot centerline.
12. Determine the Grid Shift parameter setting:

    A. Subtract the value recorded in Step 11 from –250.000.

EXAMPLE: 1. The recorded value is **–251.234**, Subtract **–251.234** from **–250.000**, the result is **+1.234**.

This indicates, Y has traveled 1.234mm beyond (plus) the 250mm stroke. Therefore the pulse coder grid position must be shifted by 1.234mm in the negative direction.

2. The recorded value is **–249.567**, subtract –**249.567** from –**250.000**, the result is –**0.433**

This indicates, Y has traveled 0.433mm short (minus) the 250mm stroke. Therefore, the pulse coder grid position must be shifted by 0.433mm in the positive direction.

B. Divide the result (Step 12 A) by 0.001, to obtain actual setting value.

C. Enter the result of Step 12 B into the Y field of parameter 1850, see section 7.11.

- If the result is a positive, enter a negative value. If the results is a negative, enter a positive value.

Z Axis Machine Zero

Z axis machine zero is set relative to the table top (Figure 7-31). The Z axis stroke (program travel) is 450mm. The minimum distance from the table top to the spindle face is 150mm.

- The total distance from machine zero to the table top should be 600mm (program travel + minimum distance from table top to spindle face).

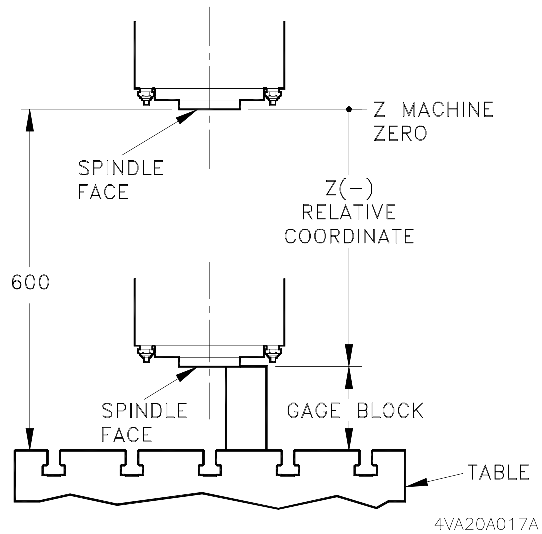


FIGURE 7-31 SETTING Z MACHINE

To Check the 600mm Distance:

1. Set the Z field of parameter 1850 to zero, see section 7.11.
2. Press [POWER OFF], to power down the machine.
3. Press [CONTROL POWER ON], to power up the machine. Perform Step 4 during machine power up.
4. Using the alpha-numeric key pad, simultaneously press [P] and [CAN] keys to cancel the stored machine zero.
5. Set the control to metric (G21).
6. Reference the Z axis.
7. Origin (set to zero) the Z axis Relative Coordinate.
8. Place a gage block of a known length on the table top beneath the spindle face. The gage block must be longer than 150mm.
9. Using the MPG, carefully move –Z until the gage block is feeler tight.
10. Record the Z relative coordinate value.
    - This negative value represents the distance Z traveled from the current machine zero position to the top of the gage block.
11. Add the gage block length to the value recorded in Step 10.
12. Determine the Grid Shift parameter setting:

A. Subtract the value recorded in Step 11 from -600.000

EXAMPLE: 1. The recorded value is **–601.234**, Subtract **–601.234** from **–600.000**, the result is **+1.234**.

This indicates, Y has traveled 1.234mm beyond (plus) the 600mm stroke. Therefore the pulse coder grid position must be shifted by 1.234mm in the negative direction.

2. The recorded value is **–599.567**, subtract –**599.567** from –**600.000**, the result is –**0.433**

This indicates, Y has traveled 0.433mm short (minus) the 600mm stroke. Therefore, the pulse coder grid position must be shifted by 0.433mm in the positive direction.

B. Divide the result (Step 12 A) by 0.001, to obtain actual setting value.

C. Enter the result of Step 12 B into the Z field of parameter 1850, see section 7.11.

- If the result is a positive, enter a negative value. If the results is a negative, enter a positive value.

7.9 Axis Covers and Chip Scraper Unit

The machine is equipped with numerous sheet metal covers enclosing the machining area to contain coolant, chips, and machine surfaces. A majority of the covers are stationary and do not require removal for maintenance procedures. This section discusses the X axis Roll-up, Y axis guide way, and ball screw covers which may require removal.

7.9.1 X Axis Roll-up Cover

The X axis roll-up cover consists of two roll-up cover assemblies (on each side of machine) mounted to frame work above the machining area with the free end of each cover attached to the saddle. As the X axis moves (plus or minus) one cover extends while the other rolls up. Roll-up is accomplished by spring loading the mechanism. A tensioning device is used to maintain proper cover tension on the roll-up mechanisms.

7.9.1.1 Roll-up Cover Tensioning

The roll-up cover tensioning mechanism consists of:

- Two wire cables, one for each roller
- Adjustable, spring loaded, tensioner with cleaves type ends for cable attachment

One wire cable is attached to each roller. The cables wrap several times around one end of each roller with the free ends connected by cleaves on both ends of the tensioner.

Attaching the Tensioning Cables:

If installing new or re-wrapping cables:

1. Make an equal number of cable wraps around each roller.
2. Check the position where the cable ends meet. They should extend approximately equal distances from each roller and far enough to allow the tensioning device to be connected.
3. Connect the cable ends to the cleaves on both ends of the tensioner.

Adjusting Cable Tension:

The tensioning device is spring loaded and should be adjusted to obtain an approximate 30mm (1 3/16") gap (Figure 7-32). The gap should be set with the internal spring compressed.

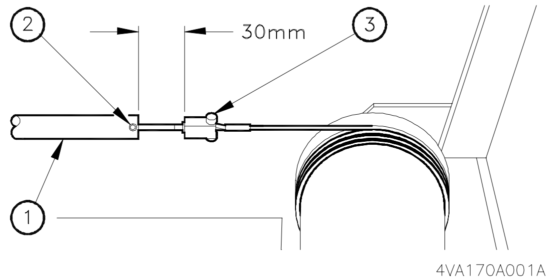


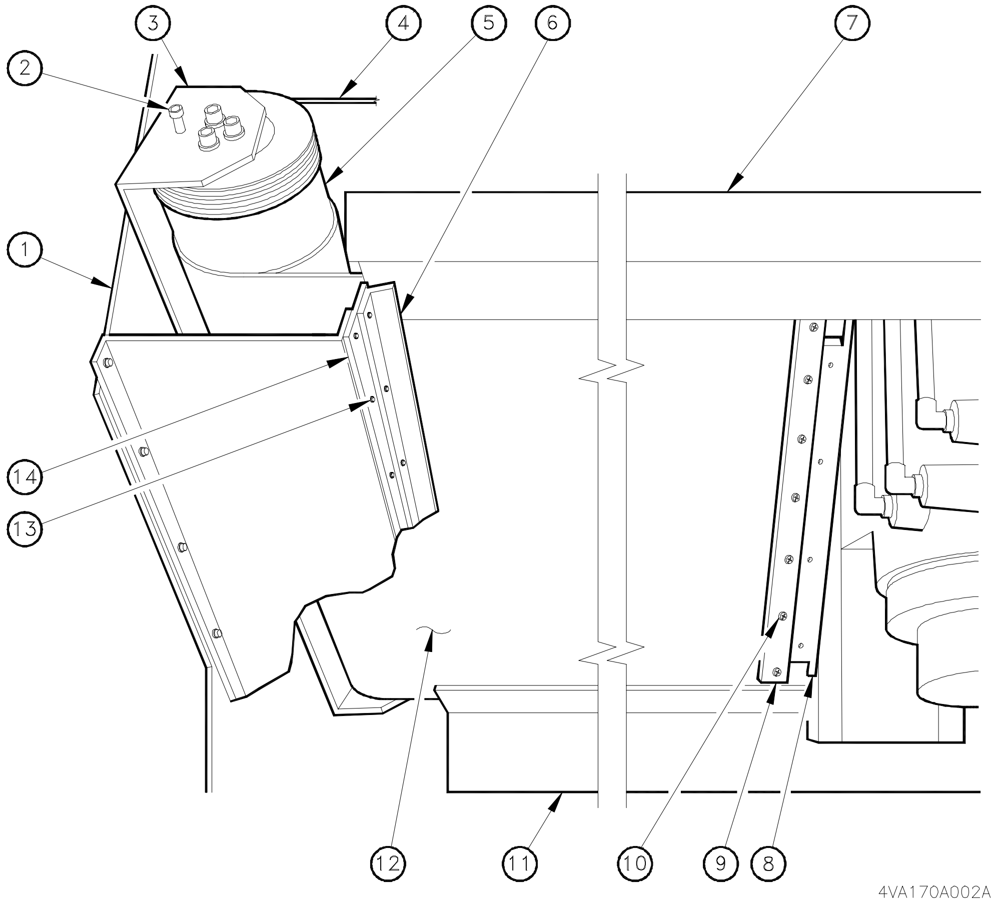
FIGURE 7-32 ROLL-UP TENSIONER

1. Loosen set screw [2] in the end of the tensioner.
2. Set the 30mm gap by threading the tensioner [1] On or Off, the threaded cleaves [3].
3. Tighten set screw [2].

After adjustment, the cable should be taut (but not over tightened) and should not droop excessively.

7.9.1.2 Roll-up Cover Removal and Disassembly

This procedure is for removing the left hand cover assembly and is the same for the right hand assembly.



Legend

[1]	Machine Framework	[8]	Saddle Cover
[2]	Locking Screw	[9]	Bracket
[3]	Housing	[10]	M5 X 8 Screws
[4]	Cable	[11]	Cover Guide
[5]	Roller	[12]	Cover
[6]	Wiper	[13]	M5 X 8 Screws
[7]	Cover Guide	[14]	Wiper Bracket

FIGURE 7-33 ROLL-UP COVER REMOVAL

To Remove the Cover Assembly:

1. Position the X axis to the minus end of stroke.
   - Y and Z can be at any position. If removing the right hand cover, reference X.
2. Turn the machine Off:
   A. Press the [POWER OFF] button.
   B. Turn the Main Power switch Off.
   C. Perform a Lockout/Tagout at the facility (machine) power source.

WARNING

Spring Loaded Mechanism

Roll-up covers are spring loaded and **MUST** be locked before being disconnected from the saddle. The roll-up mechanism is locked by a set screw, as described in Step 3.

3. Tighten the locking screw [2].
   - The following steps are performed from the upper side of the cover (outside the machining area).
4. Disconnect the tensioning cable [4].
5. Remove the bracket [9], attached to the side of the saddle cover [8]. Three (M5x8) screws (not shown).
6. Remove the bracket [14], four (M5x14) screws [13]. The wiper [6] remains attached to the bracket.
7. Detach the housing [3] to the machine framework [1]. Seven (M5x12) screws, (M5) flat washers, and (M5) lock washers (not shown).
8. Remove the cover assembly from the machine. During removal, slide the cover [12] out of its guides [7] and [11].
   - This assembly includes the housing [3], cable [4], roller [5], bracket [9], and cover [12].

To Disassemble the Cover:

1. Remove bracket [9] attached to the free end of cover [12]. Seven (M4x10) screws [10].
2. Measure and record, amount (length) of extended cover.
3. Count and record, the number of tensioner cable wraps on roller.
4. Carefully loosen the locking screw [2] allowing roll-up cover to unwind.
   - Count the number of turns to completely unroll the cover. The new cover will be pre-rolled by the same number of turns.
5. Disassemble the cover from the roller.

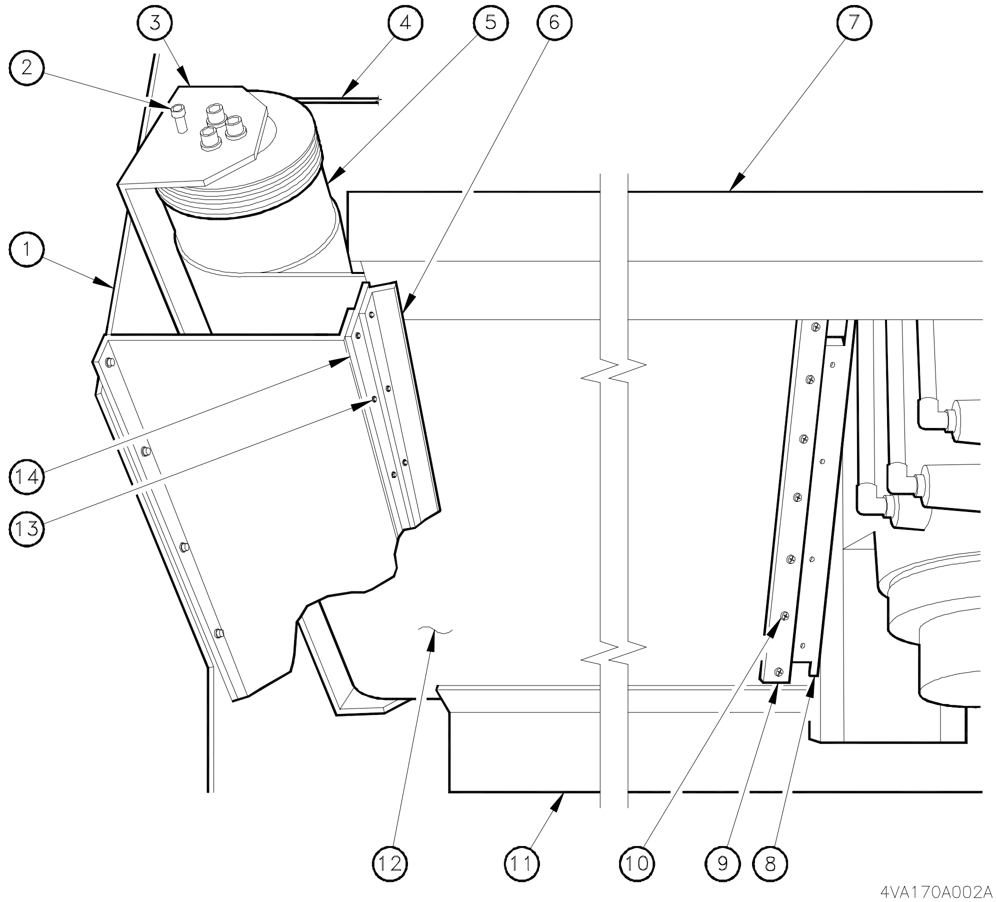
7.9.1.3 Roll-up Cover Assembly and Installation

Cover Assembly:

1. Attach the new cover to the roller.
   - Use extreme CAUTION when performing Step 2, since this step spring loads the roll-up mechanism.
2. Roll up the new cover by the same number turns used to unroll the old cover off the roller.
3. Tighten the locking screw [2].
4. Measure the amount of cover extending beyond the roller.
   - It should extend approximately the same distance measured in Step 2 in the preceding procedure “To Disassemble the Cover”.
5. Attach the bracket [9] to the free end of the cover. Seven (M4x10) screws [10].
6. Rewrap the tensioner cable [4] around the roller [5] by the same number of wraps recorded in Step 3 in the preceding procedure “To Disassemble the Cover”.

Installing the Cover Assembly:

1. Place the cover assembly into position on the machine.
2. Attach the housing [3] to the side frame work [1]. Seven (M5x12) screws, (M5) flat washers, and (M5) lock washers.
3. Slide the cover [12] through its two guides [7] and [11].
4. Attach the bracket [9] to the saddle cover [8]. Three (M5x8mm) screws.
   - It may be necessary to temporarily loosen locking screw [2] to extend the cover for attachment to the saddle cover [8]. If this is necessary, use extreme CAUTION since the roller mechanism is now spring loaded.
5. Connect the tensioner cables [4] and adjust tension if necessary, see section 7.9.1.1.
6. Install the bracket [14], with the wiper [6] attached. Four (M5x8) screws.
7. Loosen the locking screw [2].
8. Start the machine.
9. In a Manual mode, at a slow traverse rate, position the X axis back and forth while observing the roll-up and extension action of both covers.



Legend

[1]	Machine Framework	[8]	Saddle Cover
[2]	Locking Screw	[9]	Bracket
[3]	Housing	[10]	M5 X 8 Screws
[4]	Cable	[11]	Cover Guide
[5]	Roller	[12]	Cover
[6]	Wiper	[13]	M5 X 8 Screws
[7]	Cover Guide	[14]	Wiper Bracket

FIGURE 7-34 ROLL-UP COVER INSTALLATION

NOTES:

SKETCHES:

7.9.2 Y Axis Cover System

The Y axis cover system includes several covers, but consists mainly of the:

- Left hand, telescopic, guide way covers
- Right hand, telescopic guide way covers
- Y axis ball screw cover

The guide way covers expand and collapse as the Y axis (table) is positioned in and out and consist of a two piece left-hand set and a two piece right-hand set. The front and rear sections of each set are joined at the middle of the table, along the Y axis. The rear sections of each set are attached to the lower column cover and the front sections are attached to the machine bed.

- The ball screw cover is attached to and travels with the table.

For Maintenance Purposes:

Except for repairing or replacing damaged covers, the maintenance functions that require cover removal are listed below.

Left-hand guide way cover removal:

- Access to the Y axis OT2 and DEC limit switches
- Access to the left-hand guide way bearing blocks and/or rail

Right-hand guide way cover removal:

- Access to the right-hand guide way bearing blocks and/or rail

Ball screw cover:

- Access to the Y axis ball screw and ball nut
- Access to the Y axis linear feedback scales

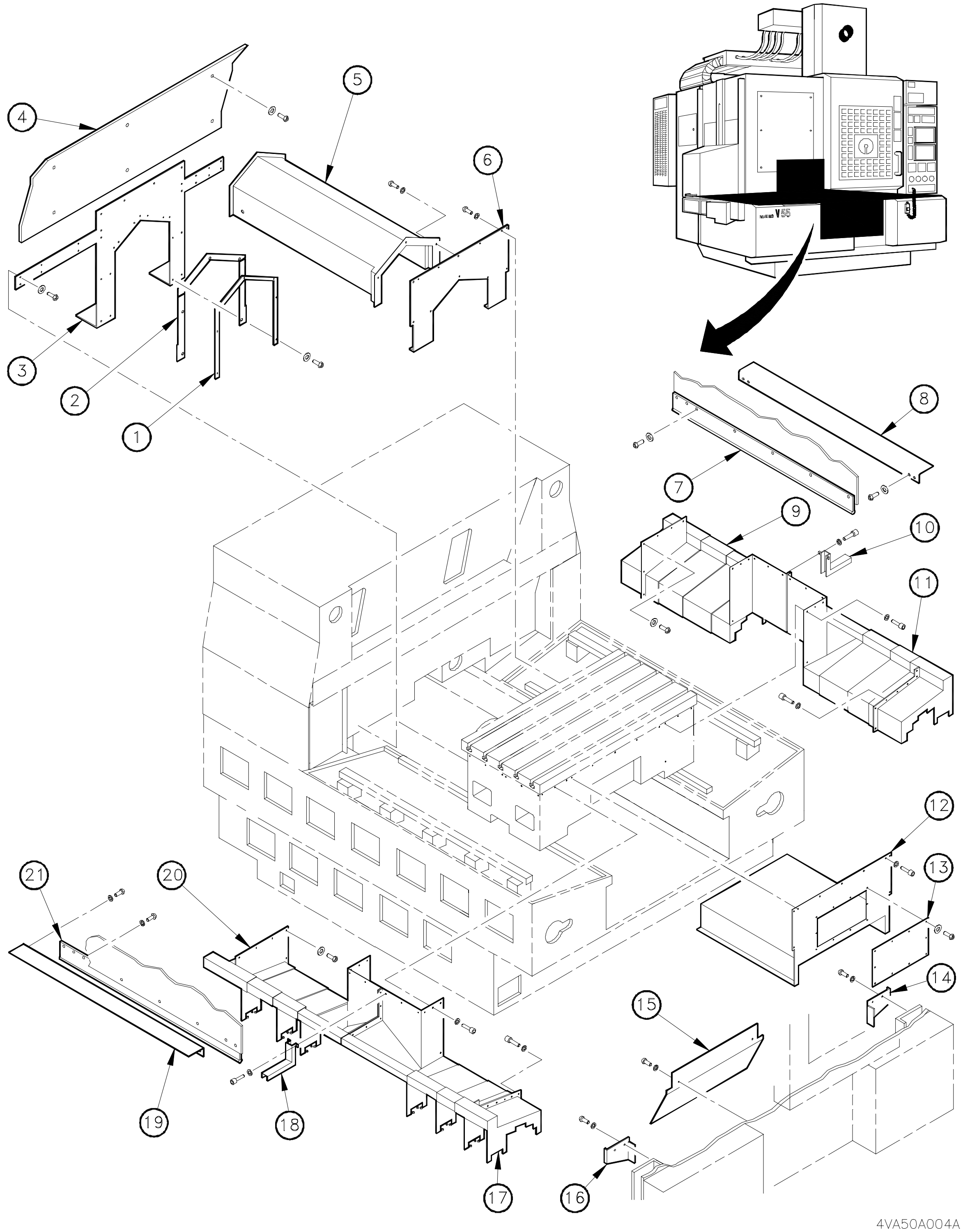


FIGURE 7-35 Y AXIS COVER SYSTEM

Figure 7-35 illustrates the Y axis cover system. Table 7-12 lists the covers and associated hardware by key number in Figure 7-35.

- Component names shown in brackets [….] are names used in the Parts Manual. Abbreviations PHS (Phillips Head or cross-head) Screw) and SHCS (Socket Head Cap Screw) are used.

TABLE 7-12 Y AXIS COVER SYSTEM AND HARDWARE LEGEND

No.	Name	Mounting Hardware		
		Type	Size	Amt.
[1]	Gasket Retainer	PHS	M5 x 8	7
[2]	Gasket (3 Pieces)	-	-	-
[3]	Lower Column Cover	PHS	M5 x 8	24
[4]	Upper Column Cover [Cover]	PHS	M5 x 25	6
[5]	Y Ball Screw Cover [Cooling Device]	SHCS (at Front)	M6 x 10	5
		SHCS (at Rear)	M6 x 8	2
		WASHER (at Rear)	M6	2
[6]	Rear Table Cover	SHCS	M6 x 12	10
		WASHER	M6	10
[7]	RH Side Cover	PHS	M5 x 8	7
[8]	RH Side Cover Bracket	PHS	M5 x 8	2
[9]	RH Rear Telescopic Cover	SHCS (at Table)	M6 x 12	7
		WASHER (at Table)	M6	7
		SHCS (at Joint)	M6 x 12	5
		WASHER (at Joint)	M6	5
		NUT (at Joint)	M6	5
[10]	Joint Cover	M6 x 12 SHCS (1 ea.) from [9] and [11].		
[11]	RH Front Telescopic Cover	SHCS (at Table)	M6 x 12	7
		WASHER (at Table)	M6	7
		SHCS (at Joint)	M6 x 12	4
		WASHER (at Joint)	M6	4
		NUT (at Joint)	M6	4
		SHCS (at Front)	M6 x 12	7
		WASHER (at Front)	M6	7
[12]	Front Table Cover [Cover (1)]	SHCS	M6 x 12	7
		Washer	M6	7

TABLE 7-12 Y AXIS COVER SYSTEM AND HARDWARE LEGEND (CONTINUED)

No.	Name	Mounting Hardware		
		Type	Size	Amt.
[13]	Lubrication Cover [(Cover (6)]	PHS	M5 x 8	10
[14]	Bracket	PHS	M5 x 8	2
[15]	Chip Deflector [Chip Cover]	PHS	M5 x 8	4
[16]	Bracket	PHS	M5 x 8	2
[17]	LH Front Telescopic Cover	SHCS (at Table)	M6 x 12	7
		Washer (at Table)	M6	7
		SHCS (at Joint)	M6 x 12	4
		Washer (at Joint)	M6	4
		Nut (at Joint)	M6	4
		SHCS (at Front)	M6 x 12	7
		Washer (at Front)	M6	7
[18]	Joint Cover	M6 x 12 SHCS (1 ea.) from [17] and [20].		
[19]	LH Side Cover Bracket	PHS	M5 x 8	2
[20]	LH Rear Telescopic Cover	SHCS (at Table)	M6 x 12	6
		Washer (at Table)	M6	6
		SHCS (at Joint)	M6 x 12	4
		Washer (at Joint)	M6	4
		Nut (at Joint)	M6	4
[21]	LH Side Cover	PHS	M5 x 8	8

NOTES:

SKETCHES:

7.9.2.1 Guide Way Cover Removal Sequence

The telescoping guide way covers can be removed in sections. Depending on the section being accessed, only certain covers must be removed. The sequence for cover removal and, where necessary, comments related to specific cover removal is described below

Right or Left Front Section Removal Sequence

This removal sequence (Table 7-13) is for the right front guide way section. This same sequence applies when removing the left front section. See Table 7-12 for the associated cover hardware.

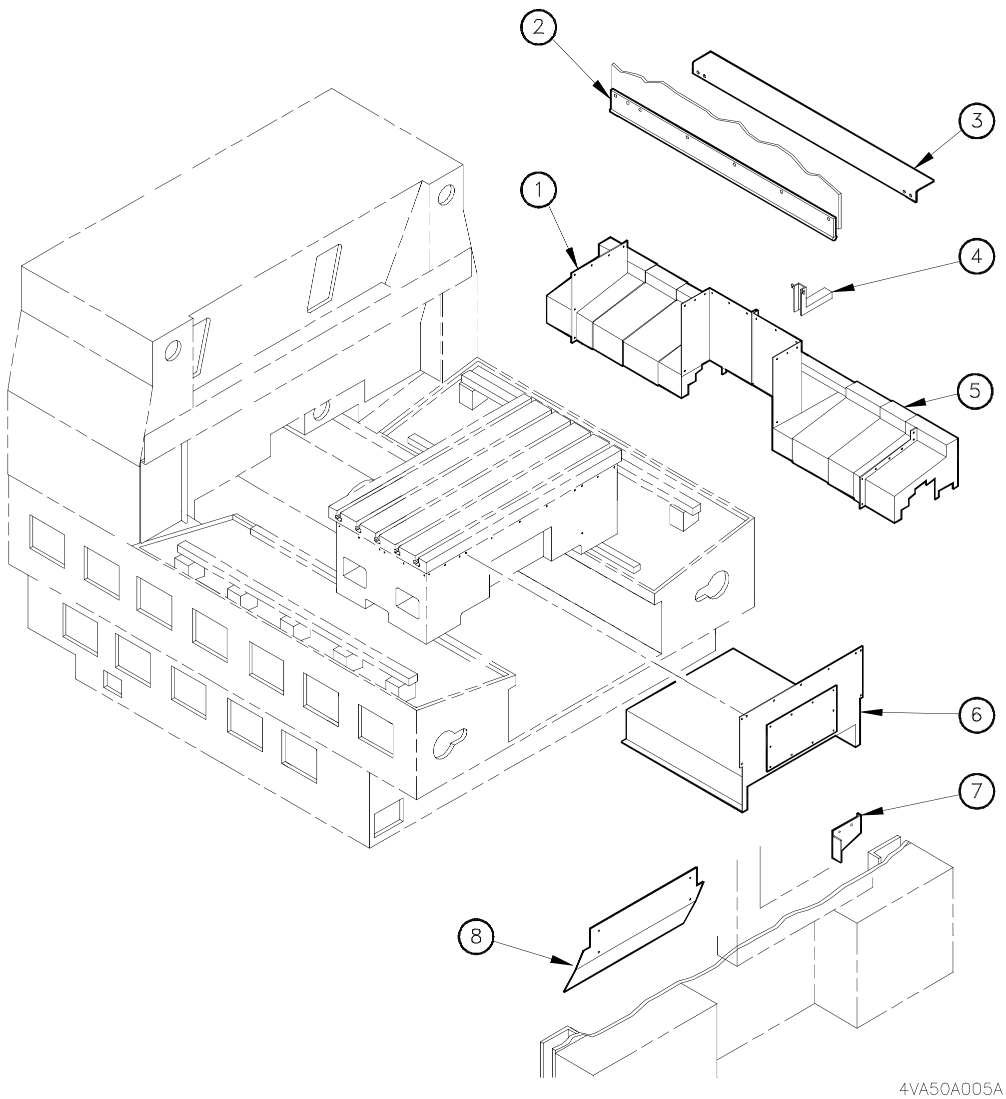


FIGURE 7-36 FRONT SECTION GUIDE WAY COVER

WARNING

Lockout/Tagout
Turn the machine Off and perform a Lockout/TagOut, before starting cover removal.

TABLE 7-13 FRONT SECTION GUIDE WAY COVER REMOVAL SEQUENCE

Seq. No.	Key No.	Name	Comments
1	[2]	Side Cover	
2	[3]	Side Cover Bracket	
3	[4]	Joint Cover	
4	[6]	Front Table Cover	
5	[7]	Bracket	
6	[8]	Chip Deflector	
7	[1] or [5]	Telescopic Covers	Remove the five (M6x12 SHCS, M6 Washers, and Nuts) attaching front and rear sections.
8	[5]	Telescopic Cover	

Right or Left Rear Section Removal Sequence

This removal sequence (Table 7-14) is for the right rear guide way section. This same sequence applies when removing the left rear section. See Table 7-12 for the associated cover hardware.

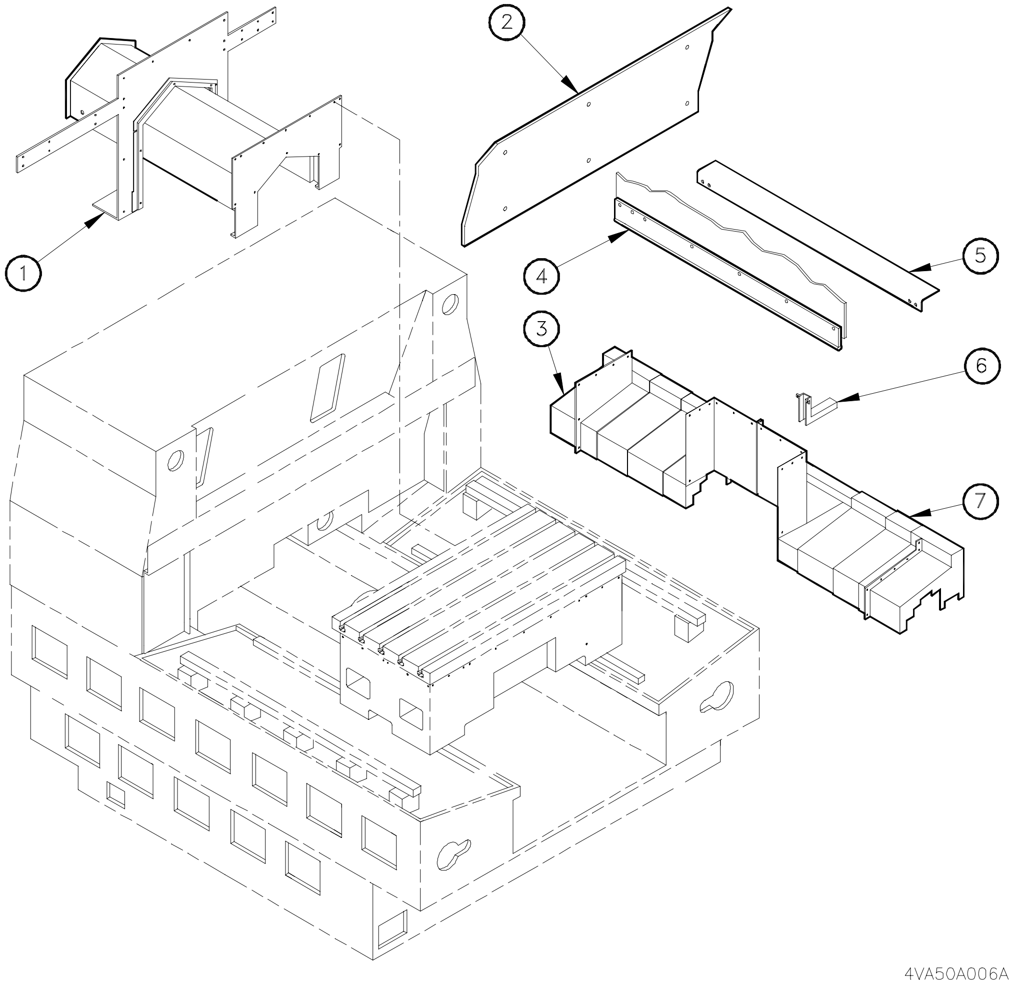


FIGURE 7-37 REAR SECTION GUIDE WAY COVER

Lockout/Tagout

WARNING

Turn the machine Off and perform a Lockout/TagOut, before starting cover removal.

TABLE 7-14 REAR SECTION GUIDE WAY COVER REMOVAL SEQUENCE

Seq. No.	Key No.	Name	Comments
1	[2]	Upper Column Cover	This cover contains an oil line for cooling the column casting. To prevent contamination and excessive oil loss, individually disconnect (4 places) and cap the oil line at the supply and return fittings.
2	[1]	Y Axis Ball Screw Cover Assembly	This assembly does not have to be completely removed. Detach the assembly from back of table and move it clear of table to access way cover [3] screws. The Y axis ball screw cover contains an oil line for cooling the ball screw housing. It is not necessary to disconnect this line.
3	[4]	Side Cover	
4	[5]	Side Cover Bracket	
5	[6]	Joint Cover	
6	[3] or [7]	Telescopic Covers	Remove the five (M6 x 12 SHCS, M6 Washers, and Nut) attaching the front and rear sections.
7	[3]	Telescopic Cover	

7.9.2.2 Ball Screw Cover Removal Sequence

Table 7-15 describes the sequence for removing covers to access the Y axis ball screw. Where necessary, comments relative to specific cover removal are provided. See Table 7-12 for the associated cover hardware.

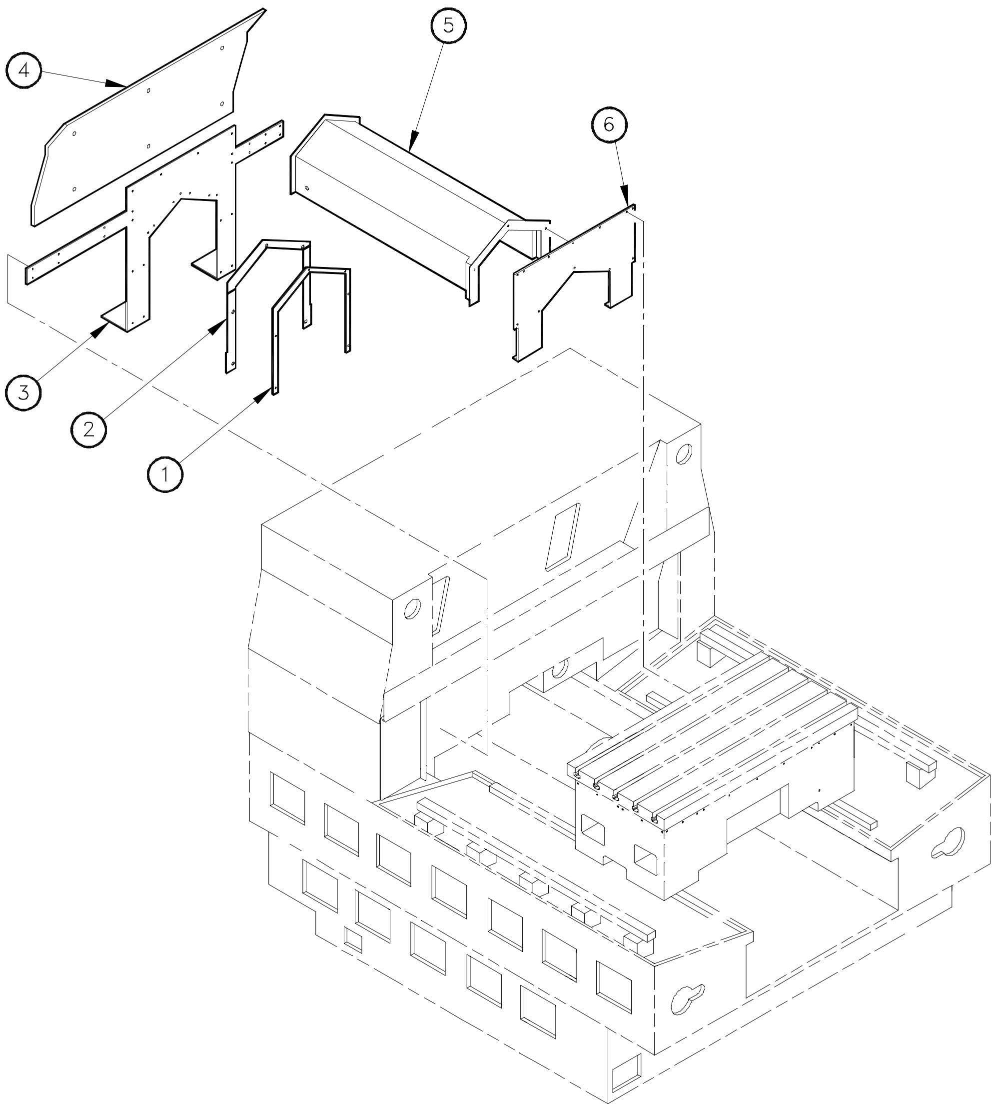


FIGURE 7-38 BALL SCREW COVER

WARNING

Lockout/Tagout

Turn the machine Off and perform a Lockout/TagOut, before starting cover removal.

TABLE 7-15 BALL SCREW COVER REMOVAL SEQUENCE

Seq. No.	Key No.	Name	Comments
1	[1]	Upper Column Cover	Remove this cover only If removing cover [3]. This cover contains an oil line for cooling the column casting. To prevent contamination and excessive oil loss, individually disconnect (4 places) and cap the oil line at the supply and return fittings.
2	[1]	Gasket Retainer	This area is sealed by gasket [2]. Be careful not to damage gasket when removing retainer [1].
3	[5]	Y Axis Ball Screw Cover	This cover contains an oil line for cooling the ball screw housing. To prevent contamination and excessive oil loss, individually disconnect (4 places) and cap the oil line at the supply and return fittings.
4	[6]	Rear Table Cover	Remove this cover only to access the under side of the table.
5	[3]	Lower Column Cover	Remove this cover only to access the under side of the column.

7.9.3 Chip Scraper Unit

The chip scraper unit is basically a built-in conveyor system used to scrape chips from beneath the table and carry them to the back of the machine for deposit in the chip pan or lift-up chip conveyor.

The unit consists of:

- An AC motor
- Two continuous chains, on each side of the unit
- Four sprockets for driving the chains, two at front and two at rear
- Two tensioners, one for each chain, located on front of unit
- A series of scrapers, attached to the chains

This unit is basically maintenance free with the exception of: maintaining proper chain tension, scraper repair or replacement, and chain alignment.

7.9.3.1 Adjusting Chain Tension

The objective in chain adjustment is to keep the chain tight to prevent it from jumping teeth on the drive sprockets. Equal tension on both chains is important for proper chain alignment.

To adjust chain tension, the chip scraper unit must be slid forward approximately 150mm (6") to access and remove the tensioner cover.

Figure 7-39 shows the left hand chain tensioner only. The number of screws, washers, and nuts specified in the procedure include the left and right sides.

At the Back of the Scraper:

1. Remove the lift-up chip conveyor or chip pan, to access the back of the chip scraper.
2. Remove the scraper motor shroud, to provide clearance for sliding the scraper unit forward.
3. Remove the two locking screws; one on each side located near the back end of scraper.

At the Front of Scraper:

4. Remove the three machine front covers [2], [3], and [4].
5. Loosen the two (M6) lock nuts [14] and (M6x25) side alignment screws [13].

6. Remove the two (M6x16) locking screws and washers [7].
7. Measure the scraper height, then loosen the two (M6) lock nuts [9] and lower scraper using the two (M6x25) jack screws [8].
8. Remove scraper alignment bracket [12]. Two (M6x12) screws and washers [11] and five (M6x14) flat head screws [10].
9. Slide the scraper unit forward to access tension adjustment cover [1].
10. Remove cover [1]. Six (M5x8) screws.
11. Loosen (M12) lock nut [5].
12. Place a 5mm hex wrench in screw [6], to prevent turning, while adjusting nut [15].
13. Adjust the chain tension with (M12) nut [15], then secure setting by tightening lock nut [5].
14. Install cover [1] and slide the scraper back into position.

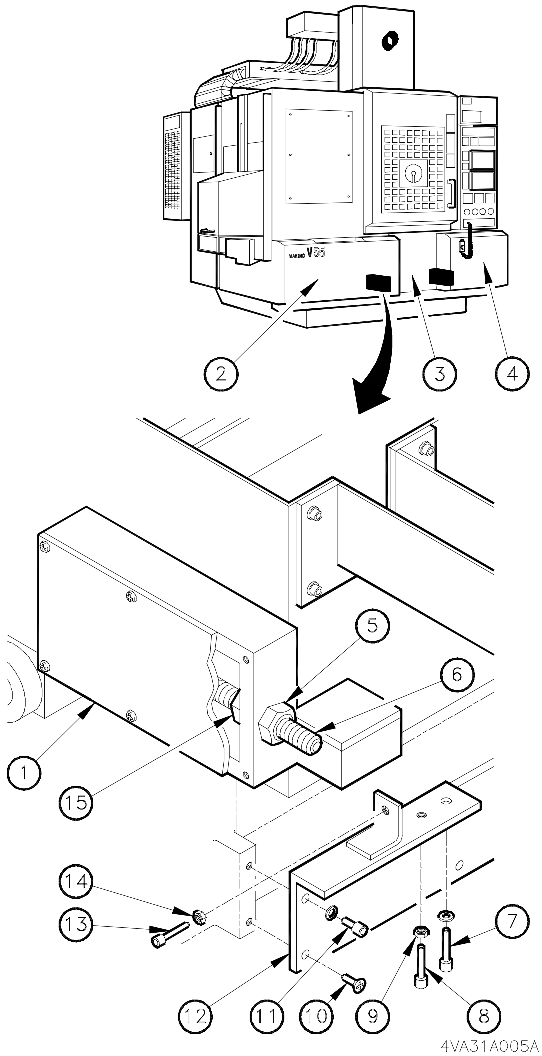


FIGURE 7-39 SCRAPER CHAIN ADJUSTMENT

15. Install alignment bracket [12] and raise the scraper, with the jack screws [8].
16. Install the locking screws and washers [7] then tighten side alignment screws [13].

At the Back of the Scraper Unit:

17. Attach the locking screws at the back scraper unit, then install the motor shroud, and place the lift-up chip conveyor, chip pan, back into position.

At the Front of the Scraper Unit:

18. Install the machine front covers [2], [3], and [4].

7.9.3.2 Scraper Repair or Replacement

Replace individual scrapers if they become damaged and are no longer effectively removing chips.

- Depending on the severity of damage, scrapers can be repaired (straighten).
- The scrapers are bolted to brackets attached to the chains (Figure 7-40).

To Replace a Scraper:

1. Position the Y axis to its full plus end of stroke.
2. Run the chip scraper until the damaged scraper is accessible at the front of the table.
3. Unbolt and remove the old scraper. One (M10x20) screw [7], two (M10) washers [4], and one nut [3] on each side.
4. Install the new or repaired scraper.

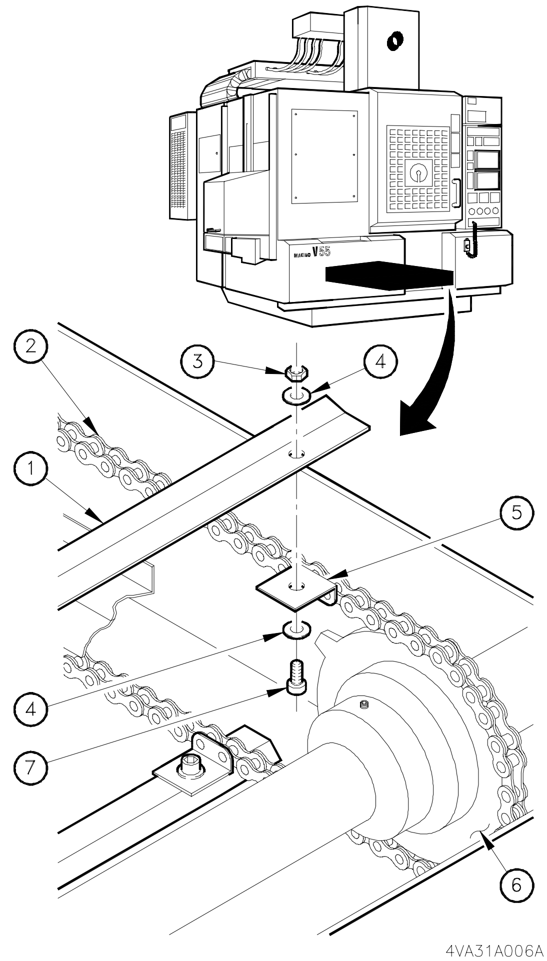


FIGURE 7-40 SCRAPER REPLACEMENT

7.9.3.3 Chain Alignment

The two chip scraper chains should be aligned so that the scrapers are perpendicular to the chains. The major cause of chain misalignment is a chain jumping a tooth on a drive sprocket. This is typically caused by a chip jam as the result of excessive chip build-up.

1. Adjust the chain tensioners until both chains are relaxed, section 7.9.3.1.
2. Reset the chain links in the front drive sprockets until the scrapers are perpendicular to the chains.
3. Readjust the chain tension.

7.10 Axis Position Compensation

There are two axis positioning compensation systems on the V55. These compensation systems are backlash and pitch error and reside in the CNC.

These compensations are set at the factory.

As with any compensation system be aware:

- Improper compensation values can create what appears to be a machine problem or magnify a mechanical problem in the feed axis system.
- Use of this compensation function may only mask a true mechanical problem, resulting in excessive wear or component damage.

Main causes of backlash in the feed system are:

- Elastic deformation of the ball screw.
- Insufficient or improper guide way or ball screw lubrication.
- Loose or damaged ball screw support bearings. Check ball screw for end play and proper pretension amount.
- Ball screw wear.

7.10.1 Feed Axis Backlash

Backlash is a term used to refer to the amount (distance) of lost motion, in an axis during change of direction. Excessive backlash adversely affects the accuracy of the machine tool.

This lost motion may be caused, in part, by any of the components in the feed mechanism. Historically the causes of backlash were mechanical in nature, however modern controls allow for the electronic compensation of backlash through the servo system.

7.10.1.1 Measurement of Axis Backlash

This procedure is used to measure an axis' backlash. Measure backlash at three points along the axis, then use an average of these measurements as the backlash amount.

If the backlash check readings are high (0.02mm (0.0008")), inspect the entire feed mechanism for possible mechanical failures. Check the: guide ways for wear and proper lubrication; ball screw and support bearings for wear and proper lubrication; ball screw pre-tension.

Before starting this procedure, set the backlash amount in CNC parameter 1851 (for the axis being measured) to zero. See section 7.11 for the procedure to set parameter 1851.

This procedure is for measurement along the X axis. Y and Z axes are measured in a similar manner.

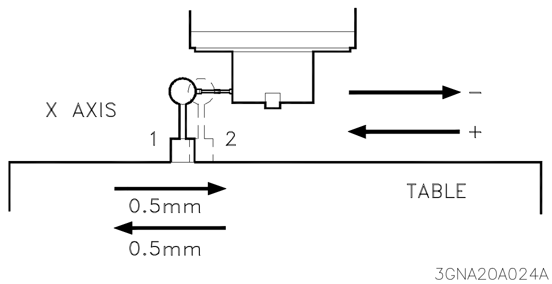


FIGURE 7-41 BACKLASH MEASUREMENT (X SHOWN)

1. Mount a magnetic base and 0.002mm or 0.0001" indicator on the table.
2. In HANDLE mode, move the X, Y, and Z axes so the spindle nose contacts the indicator stylus. Position **1** in Figure 7-41.
   - Indicate against the spindle end cap and not against the spindle cooling jacket.
3. Using the MPG, move the axis to position **1** to load the indicator and set it to zero. Load the indicator in the same direction of axis travel used in Step 2.
   - While performing this step, do NOT change the direction of axis travel, as this will produce a false backlash reading.
4. Set the Rapid-Traverse rate to 100%.
5. In MDI, command an incremental move of 0.5mm (0.020"), further loading the indicator (move from position **1** to position **2**).
   - Key-in: G21 G91 X–.5, [EOB], [INSERT], and press Cycle [START].
6. Command the same distance move in the opposite direction (from position **2** back to position **1**).
   - Key-in: G21 G91 X.5, [EOB], [INSERT], and press Cycle [START].

7. Record the indicator reading. Pay attention to + and – reading relative to indicator zero
   - The indicator reading represents the backlash amount.
8. Repeat steps 1 through 7 at two equally spaced positions, along the same axis.
9. Average the three backlash measurements, to obtain the amount of backlash to enter into parameter 1851.
10. Compensate the backlash, if the average exceeds 0.016mm (0.0006").

Backlash

Removing all backlash is not advisable: however with the current state of servo control, the elimination of all backlash as viewed by the indicator is allowed. If problems in circular interpolation are found after adjustment, contact your Makino service group.

7.10.2 Pitch Error Compensation

On a standard machine, axis position is detected by the pulse coder mounted on the end of the axis servo motor. Pitch error compensation allows inaccuracies in the pitch of the ball screw to be corrected.

Pitch error compensation allows servo feed pulses to be increased or decreased at different positions along the screw. These positions are determined by measuring the accumulative positioning error along the axis. Measurement is performed with a laser at final assembly of the machine and compensation is input.

Pitch Error

1. Pitch error compensation is not considered a regular maintenance item. Pitch error would only be required in cases where a new ball screw is installed. Be certain to check and eliminate all other possible reasons for positioning error before checking or changing the pitch error values on the machine.
2. Improper set up or compensation for the laser may affect the accuracy of pitch error measurement, be certain to check with your Makino service group for details and assistance.

7.11 Setting CNC Parameters

Certain maintenance functions require setting or adjusting related CNC parameters to restore the machine to original operating condition. The following procedure provides the basic steps to set CNC parameters. Setting values differ depending the parameter number. Refer CNC Maintenance Manual details related to specific parameter setting values.

The parameters subject to setting or adjustment include:

- 1850 Grid Shift, see section 7.8.7.2
- 1851 and 1852 Backlash, see section 7.10.1.1

The control provides the capability to “password” protect the CNC parameters. If active, the password must be known in order to activate the Parameter Write Enable function.

1. Activate PWE (Parameter Write Enable) to unlock CNC parameters.
   A. Select MDI mode.
   B. Press the [OFFSET SETTING] function key.
   C. Press the [SETING] softkey, to select the (SETTING HANDY) screen.
   D. Select the PARAMETER WRITE field.
   E. Key-in a ’1’ and press [INPUT].
2. Press the [SYSTEM] function key.
3. Key-in the required parameter number press the [NO. SRCH] softkey.
4. If the parameter has separate fields for the X, Y, and Z axes. Use the cursor keys to highlight the field to be set.
5. Key-in the parameter setting value and press the [INPUT] key.
6. Deactivate PWE, locking the parameters.
   A. Press the [OFFSET SETTING] function key.
   B. Press the [SETING] softkey, to select the (SETTING HANDY) screen.
   C. Select the PARAMETER WRITE field.
   D. Key-in a ’0’ and press [INPUT].
   E. Press the [RESET] key, to clear the alarm.
   F. Press the [CONTROL POWER OFF] button, to turn the control Off.

These CNC parameters require the control be turned Off then back On, before the parameter change takes effect.

7.12 Periodic Maintenance

Check the following items, at the recommended frequencies, to ensure proper machine performance, accuracies, and capabilities, are and maintained, throughout its life.

7.12.1 Daily Checks

1. Check main system air pressure; pressure should be set at 0.5 MPa (70 psi).
2. At the end of each shift, clean chips and machining contaminates from all way covers.

- Do NOT use air to clean the axis way covers!

7.12.2 Semi-annual Checks

1. Check machine level, adjust as necessary.
2. Grease the axis ball nuts and LM guides, see section 7.12.3.
3. Check the guide way wipers for improper fit or wear, replace as necessary.
   - The wipers are located around the ends of each guide way block and provide a seal to prevent graphite and other contaminants from entering the guide way bearing blocks.

PM Schedule

This schedule is based on an 8 hour day, 40 hour week. Therefore one year is approximately 2,000 hours of operation.
See chapter 3 for more detail and information pertaining to PM and Lubrication of the machine tool components, recommended oils, greases, fill points, frequencies, etc.

7.12.3 Axis Lubrication

Proper axis lubrication is essential to maintaining smooth and consistent axis movement and positioning accuracy.

- A axes LM guides and ball nuts are lubricated from two distribution points.
- A grease gun is provided for greasing the ball nuts, LM guides, ATC, and APC mechanisms.
- Over lubrication can cause excessive friction and heat buildup leading to undesired wear.

Each LM guide is equipped with a grease fitting for periodic lubrication. Grease each guide every six months or 1,000 hours of operation or when change in grease color (indicating breakdown of composition) occurs.

Each ball nut is equipped with a grease fitting for periodic lubrication. Grease each ball nut once a year or every 2,000 hours of operation.

- Lubricate only with Kluber NBU 15 grease, or equivalent. See section 7.12.3.1 for lubrication points and procedures and chapter 3 for more information on lubricants and lubrication.
- Each LM guide and ball nut is equipped with seals to retain grease and prevent contamination of the re-circulating balls. It is normal for a small amount of grease to escape from the seals.

7.12.3.1 X and Z Axes Lubrication Points

The grease fittings for the X and Z axes LM guides and ball nuts are accessed by positioning X (saddle) to the plus end of travel and opening the column cover located to the left of the Hydraulic and Air Compartment. See Figure 7-42.

X and Z Lubrication Procedure:

1. Reference the X axis.
2. Open the lubrication access door, located on the right hand side of the machine.
3. Using Figure 7-42 or machine mounted lubrication plate, locate the fittings for the component (LM guides or ball nut) being lubricated.
   - Four grease fittings for the X axis guide blocks
   - Six fittings for the Z axis guide blocks
   - One fitting each for the X and Z ball nuts
4. Using Kluber NBU 15 grease, or equivalent:
   - Inject 8cc's of grease into each X axis guide block fitting
   - Inject 6cc's of grease into each Z axis guide block fitting
   - Inject 40cc's of grease into each ball nut fitting

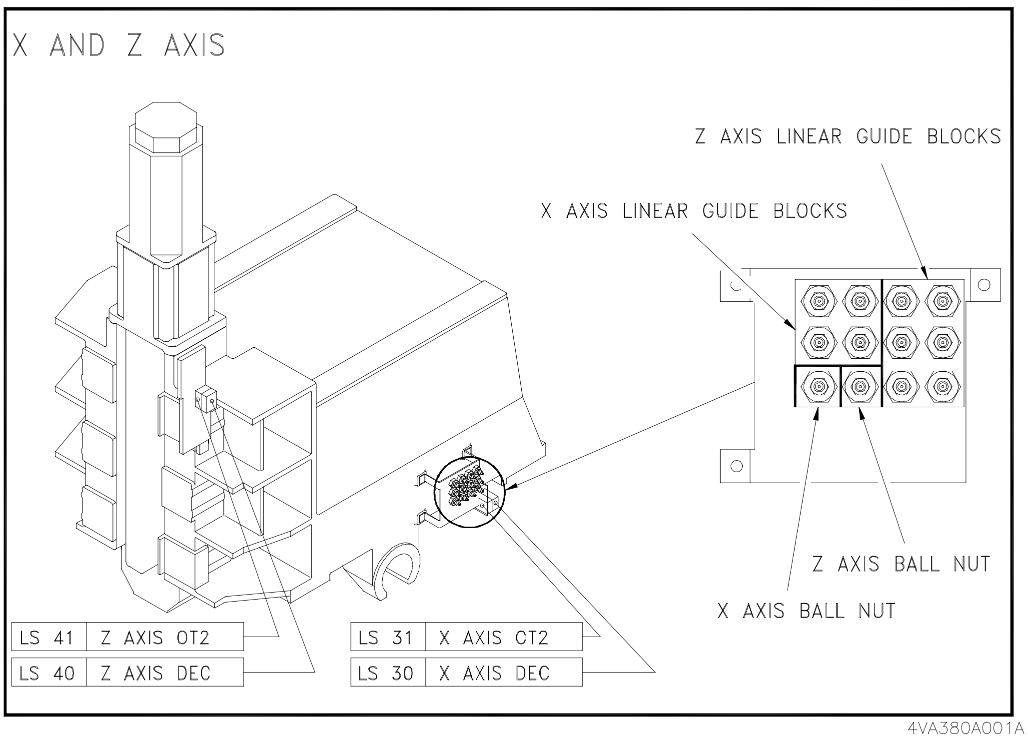


FIGURE 7-42 X AND Z LM GUIDE AND BALL NUT LUBRICATION POINTS

7.12.3.2 Y Axis Lubrication Points

The grease fittings for the Y axis LM guides and ball nut are accessed by positioning the Y axis to its mid-stroke position and removing the cover from the front of the table. See Figure 7-43.

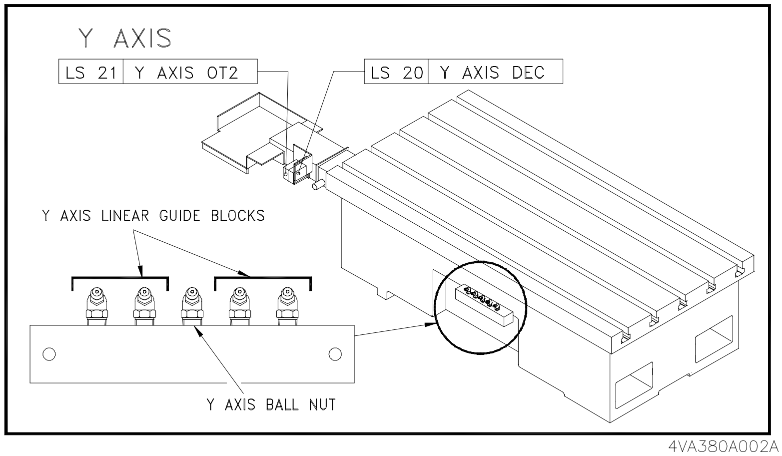


FIGURE 7-43 Y LM GUIDE AND BALL NUT LUBRICATION POINTS

Lubrication Procedure:

1. Position Y (table) to about mid-stroke.
2. Remove the cover from the front of the table. Ten (M5x8) screws.
3. Using Figure 7-43 or machine mounted lubrication plate, locate the fittings for the component (LM guide or ball nut) being lubricated.
   - Four grease fittings for the Y axis guide blocks
   - One fitting for the Y ball nut
4. Using Kluber NBU 15 grease or equivalent:
   - Inject 8cc's of grease into each guide block fitting
   - Inject 40cc's of grease into the ball nut fitting

NOTES:

SKETCHES:

NOTES:

SKETCHES:

Chapter 8 A25 ATC (Automatic Tool Changer) Unit

4V61A Type

25 Tool Armless Magazine

Makino V55 High-speed Vertical
Machining Center

MAKINO

Chapter 8
A25 ATC (Automatic Tool Changer) Unit

Contents

NOTES:

SKETCHES:

8.1 Overview

The V55 is available with a 25 tool magazine ATC (Automatic Tool Changer). The ATC is armless type tool changer, referred to as an A25. The ATC unit is located on the left side of the machine and isolated from the machining area by an air operated ATC shutter (door).

The A25 is a bi-directional carousel type magazine that indexes (rotates) the commanded tool to the tool change position. Magazine indexing occurs automatically when a T code is commanded. The magazine is driven by a Fanuc servo motor and controlled by the servo drive unit.

Tools are held in the magazine by 25 sets of spring loaded grippers (fingers). The grippers are numbered sequentially (1 to 25), but tooling may be called randomly via the part program or MDI.

Tool changes are accomplished by positioning the machine axes to the tool change position where the spindle picks the tool from the magazine. This design eliminates a tool change arm mechanism for exchanging tools between the magazine and spindle.

- Tooling is hydraulically unclamped (released) and mechanically clamped (retained in) the spindle. See chapter 6 for details on the spindle clamp/unclamp mechanism.

A safety interlocked, manually operated, ATC door provides operator access to the magazine for loading and unloading tools. An ATC Operation Panel, to the right of the ATC door, provides complete manual operation of the magazine. This panel is also equipped with an E-Stop (Emergency Stop) button.

8.2 Principles of Operation

Several operating principles, beyond the ATC mechanism(s), should be understood and considered when troubleshooting or operating the ATC. These include the:

- ATC Operation Panel
- Sequence of events
- ATC standby conditions
- ATC positions
- Tool change program

8.2.1 ATC Operation Panel

Figure 8-1 shows the ATC Operation Panel, its buttons and operation are described below.

[EMERGENCY] Stop (E-Stop) – This safety feature, halts all machine motion. Pressing the [EMERGENCY] button immediately stops the following:

- Axis motion
- Spindle rotation
- All coolant flow
- ATC motion
- APC motion

Power the CNC remains On and the [EMERGENCY] button is latched in the On position.

To reset an E-Stop condition:

1. Turn the [EMERGENCY] button in the direction of the arrows, on the button face.
2. Press [CONTROL POWER ON].
3. Perform manual Reference Return for all axes.
4. Reset the ATC, APC, and other external devices.

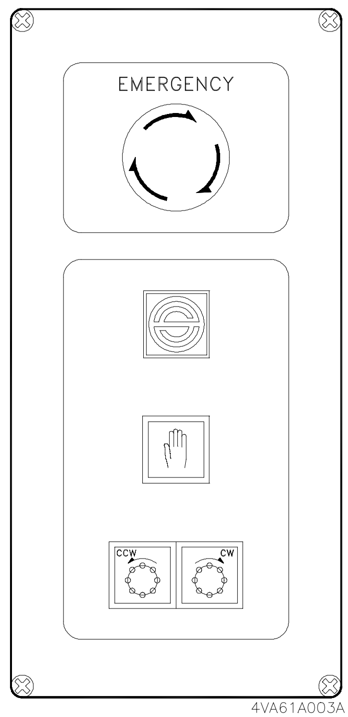
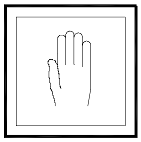


FIGURE 8-1 ATC OPERATION PANEL

If an E-Stop condition was caused by other than pressing an [EMERGENCY] button, determine and correct the cause before resuming operation.



[Manual Interrupt] – Toggles the ATC unit between manual (**X01.5 = 1**) and automatic (**X01.5 = 0**) mode.

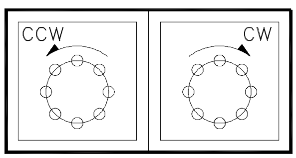
In automatic mode (button lamp Off (**Y05.7 = 0**)); the ATC functions normally and opening the ATC door interrupts machine operation and generates an alarm.

In manual mode (button lamp On (**Y05.7 = 1**)); automatic tool changes are inhibited and the ATC door can be opened without interrupting machine operations, for loading and unloading the magazine. Manual magazine indexing with the [CW] and [CCW] buttons is permitted.

If [MANUAL INTERRUPT] is pressed during ATC operation, the lamp flashes. When the tool change is complete, the lamp On steady indicating that Manual Interrupt is active.

- A Machine alarm is generated if the ATC door is opened while the Manual Interrupt lamp is flashing.

If a tool change command is executed while Manual Interrupt is active, the tool change is suspended and automatically resumes when Manual Interrupt is turned Off.



Magazine Index [CW] – Indexes the tool magazine in the CW (Clockwise) direction, when pressed (Manual Interrupt active). CW indexes to higher pot numbers.

When [CW] is pressed (**MZR X01.6 = 1**) the magazine indexes, when released (**X01.6 = 0**) the magazine indexes one position CW and stops.

Magazine Index [CCW] – Indexes the tool magazine in the CCW (CounterClockWise) direction, when pressed (Manual Interrupt active). CCW indexes to lower pot numbers.

When [CCW] is pressed (**MZR X01.7 = 1**) the magazine indexes, when released (**X01.7 = 0**) the magazine indexes one position CCW and stops.

8.2.2 ATC - Sequence of Events

Tools loaded into the magazine must have PTN's (Programmed Tool Numbers) assigned for identification within the machine tool system. A PTN represents the T-code assigned in the part program. the tools in the magazine must then be registered in the PMC to assign the PTN to a magazine (pot) location, see section 8.2.6 (pg 8-11) for detail on tool registration.

After tooling is loaded and registered the PMC can index the commanded tool to the ready position when a T code (i.e T15;) is commanded. When a tool change is commanded (M6;) the PMC initiates a tool change in one of the sequences described below.

Tool Change Sequence - No Tool in Spindle:

With no tool in the spindle, the tool change need only pick up a tool from the magazine. When a tool call and tool change are commanded,

T15;
M6;

the following sequence occurs:

1. The magazine indexes placing tool T15 in the ready position.
2. Tool change program O9020 is called and initiated.
3. Z axis references.
4. Y axis moves to 2nd reference position.
5. ATC shutter opens.
6. Spindle stops and orients.
7. X axis moves to 2nd reference position (X tool change position).
8. Spindle unclamps.
9. Z axis moves to 2nd reference position (Z tool change position).
10. Spindle clamps.
11. X axis moves to machine coordinate X-900mm, removing tool from magazine.
12. Z axis moves to 1st reference position.
13. ATC shutter closes.
14. Tool change complete.
15. Return to machining operations.

Tool Change Sequence - Tool in Spindle:

With a tool clamped in the spindle, the tool change must first unload the spindle tool, then pick up the commanded tool. When a tool call and tool change are commanded,

T15;
M6;

the following sequence occurs:

1. The magazine indexes placing tool T15 in the ready position.
2. Tool change program O9020 is called and initiated.
3. Z axis references.
4. Y axis moves to 2nd reference position.
5. Spindle stops and orients.
6. The pot for the spindle tool, at ready position, is confirmed as empty.
7. ATC shutter opens.
8. X axis moves to machine coordinate X-900mm.
9. Z axis moves to 2nd reference position (Z tool change position).
10. X axis moves to 2nd reference position (X tool change position).
11. Spindle unclamps.
12. Z axis moves +115mm (clearance position for magazine index).
13. Magazine indexes commanded tool to ready position.
14. Z axis moves to 2nd reference position (Z tool change position).
15. Spindle clamps.
16. X axis moves to machine coordinate X-900mm, removing tool from magazine.
17. Z axis moves to 1st reference position.
18. ATC shutter closes.
19. Tool change complete.
20. Return to machining operations.

8.2.3 ATC Standby Condition

ATC Standby is a conditional check, made by the PMC, confirming that the ATC unit is in the proper state to perform a tool change. The PMC determines Standby condition by viewing the status of specific inputs and outputs.

- If Standby is NOT present or lost during operation, an INTERLOCK is issued to stop axes movement and inhibit the tool change.

Figure 8-2 shows the ATC MAINTENANCE screen with the conditions for Standby indicated by an (!) symbol.

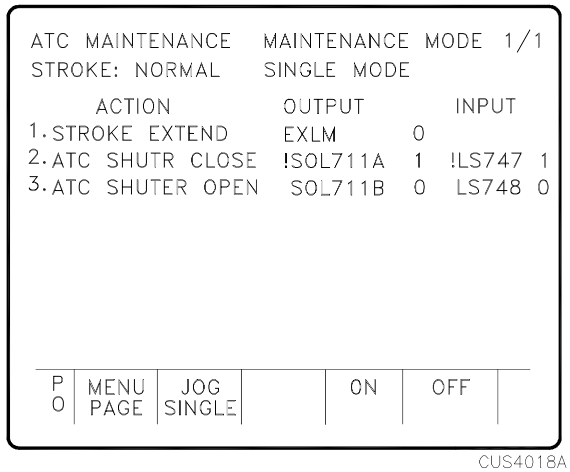


FIGURE 8-2 ATC MAINTENANCE SCREEN

STANDBY CONDITIONS

	Signal Name	Diagnostic Status
	EXLM	G507.6 = 0
d	LS747 and LS748	X01.1 = 1 and X01.2 = 0
	SL711A and SL711B	Y05.6 = 1 and Y05.7 = 0

8.2.4 ATC Positions

The ATC unit has several different positions that must be properly set, or defined, to complete an automatic tool change. These positions include:

- Tool magazine ready position; radial location of pot. Established by the 6th axis word of Grid Shift parameter 1850.
- X tool change position; X position where spindle centerline is in-line with pot centerline. Established by the X axis word of 2nd reference position parameter 1241. The X position can only be reached when the Stroke Extend mode is On.
- Z tool change position; Z position where tool holder is gripped and released while in the magazine. Established by the Z axis word of 2nd reference position parameter 1241.
- Z tool clear position; Z position where spindle face clears tool holder retention knob for magazine indexing to next tool. Commanded as a +Z 115mm incremental move, above the Z axis 2nd reference position.
- X tool clear of magazine position; X position where tool holder clears the magazine for indexing to the next tool. Commanded as a –X 1085mm, machine coordinate position. This X position can only be reached when the Stroke Extend mode is On.

See section 8.9 for procedures to check the tool magazine ready and the X and Z tool change positions.

8.2.5 ATC Tool Change Program - O9020

Tool Change Program O9020 is a macro program, stored in the CNC memory during machine setup, and is the primary program executed when a tool change is commanded. If the machine is equipped with the ATLM (Automatic Tool Length Measurement) option, its macros and sub programs were also installed and when O9020 is executed, it calls two of these macros during tool change operations.

Tool changes are commanded from the part program or MDI by a T code (Txxxx) and M06, placed in separate blocks.

- Txxxx represents the PTN (i.e. T9)
- M06 is set by CNC parameter 6080 to call macro program O9020.

The tool change program is presented in section 8.2.5.1, for reference and in the event the program is deleted from the CNC.

8.2.5.1 O9020 - Program Description

Table 8-2 presents the tool change program O9020 (left column) with a block-by-block description (right column). For troubleshooting, this program executes one block at a time in [SINGLE BLOCK].

- In this program, # is read as variable and #0 is read as vacant. #0 is used in conditional expressions to test for missing variable data.

TABLE 8-2 ATC PROGRAM AND DETAIL

Program	Detail
9020 (V55 ATC15/25 AND TLS VER.4) ;	Program# and identifying comment
M5 ;	Spindle stop
G91 G28 Z0 ;	Z reference
G91 G30 Y0 ;	Y 2nd reference
#16 = #104 ;	Sets #16 = value in #104
M621 ;	Begin tool change sequence
#14 = #4001 ;	Sets #14 to value of group 1 G code
#15 = #4003 ;	Sets #15 to value of group 3 G code
G53 ;	Activates machine coordinate system
#10 = 1 ;	Used to divide and return millimeters
#12 = -900 ;	Sets #12 = –900.000
IF [#4006EQ21] GOTO10 ;	Jump to N10 if G21 (Metric) is active
#10 = 25.4 ;	Used to divide millimeters and return inches
#12 = -35.433 ;	Used as max. travel in –X direction)
N10 IF [#20EQ#0] GOTO20 ;	Skip O9613 call, if #20 is vacant
M05 ;	Spindle stop
G65 P9613 A#1 B#2 C#3 I#7 J#17 K#6 E#23 F#26 H#20 M#13 R#18 S#19 Y1. ;	Calls macro O9613 and transfers argument data
IF [#104EQ1] GOTO130 ;	Jump to N130 if #104 = 1
IF [#104EQ5] GOTO130 ;	Jump to N130 if #104 = 5
IF [#104GE4] GOTO70 ;	Jump to N70 if #104 is Š 4
G91 G30 Y0 ;	Y 2nd reference
N20 IF [#104EQ1] GOTO140 ;	Jump to N140 if #104 = 1
IF [#104EQ5] GOTO140 ;	Jump to N140 if #104 = 5
IF [#104NE0] GOTO40 ;	Jump to N40 if #104 ¼ 0
M559 ;	
G40 ;	Cancel cutter radius compensation

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TABLE 8-2 ATC PROGRAM AND DETAIL (CONTINUED)

Program	Detail
G91 G30 X0. Z0. M663 ;	X and Z 2nd reference
G49 ;	Cancel tool length compensation
G91 G0 Z[105/#10] M663 ;	Incremental Z positive move of 105 mm/1
G91 G30 Z0. M663 ;	Z 2nd reference
IF [#11EQ#0] GOTO30 ;	Jump to N30 if #11 is vacant
G90 G53 G0 X[-1085/#10] ;	X move (machine coordinate)
G91 G28 Z0. ;	Z references
G65 P9611 I#4 J#5 E#8 F#9 H#11 R#18 U#21 V#22 Y1. ;	Calls macro O9611 and transfers argument data
GOTO140 ;	Unconditional jump to N140
N30 G90 G53 G0 X#12 ;	X move (machine coordinate)
G#14 G#15 M948 ;	Resets G code in #14 and #15
#104 = #16 ;	Sets #104 = to #16
GOTO150 ;	Unconditional jump to N150
N40 IF [#104EQ2] GOTO50 ;	Jump to N50 if #104 = 2
IF [#104EQ3] GOTO60 ;	Jump to N60 if #104 = 3
GOTO70 ;	Unconditional jump to N70
N50 M559 ;	
G40 ;	Cancel cutter radius compensation
G91 G30 X0. Z0. M663 ;	X and Z 2nd reference, begin change sequence
G49 ;	Cancel tool length compensation
G91 G0 Z[115/#10] M663 ;	Incremental Z positive move
G90 G53 G0 X#12 ;	X move (machine coordinate)
G91 G30 Z0. ;	Z to 2nd reference
GOTO140 ;	Unconditional jump to N140
N60 M559 ;	
G40 ;	Cancel cutter radius compensation
G90 G53 G0 Z[-75/#10] ;	Z move (machine coordinate)
G49 ;	Cancel tool length compensation
G91 G30 X0. M663 ;	X 2nd reference
G91 G30 Z0. M663 ;	Z 2nd reference
GOTO100 ;	Unconditional jump to N100
N70 G91 G28 Z0. M319 ;	Simultaneous Z references and spindle orient
G49 ;	Cancel tool length compensation

TABLE 8-2 ATC PROGRAM AND DETAIL (CONTINUED)

Program	Detail
IF [#104EQ7] GOTO90 ;	Jump to N90 if #104 = 7
G90 G53 G0 X[-1085/#10] ;	X move (machine coordinate)
M559 ;	
G40 ;	Cancel cutter radius compensation
IF [#104EQ6] GOTO80 ;	Jump forward to N80 if #104 is equal to 6
G91 G30 X0. Z0. M663 ;	X and Z 2nd reference
G91 G0 Z[105/#10] M663 ;	Incremental +Z move
G91 G30 Z0. M663 ;	Z 2nd reference
GOTO100 ;	Unconditional jump to N100
N80 G91 G30 X0. Z0. M663 ;	X and Z 2nd reference
G91 G28 Z0. M663 ;	Z reference
G90 G53 G0 X#12 ;	X move (machine coordinate)
GOTO140 ;	Unconditional jump to N140
N90 M559 ;	
G40 ;	Cancel cutter radius compensation
G91 G30 X0. M663 ;	X 2nd reference
G91 G30 Z0. M663 ;	Z 2nd reference
N100 IF [#11EQ#0] GOTO110 ;	(ump to N110 if #11 is vacant
G90 G53 G0 X[-1085/#10] ;	X move (machine coordinate)
G91 G28 Z0. ;	Z reference
G65 P9611 I#4 J#5 E#8 F#9 H#11 R#18 U#21 V#22 Y1. ;	Calls macro O9611 and transfers argument data
GOTO140 ;	Unconditional jump forward to N140
N110 IF [#104GE4] GOTO120 ;	Jump to N120 is #104 is ≥ 4
G90 G53 G0 X#12 ;	X move (machine coordinate)
GOTO140 ;	Unconditional jump to N140
N120 G90 G53 G0 X[-1085/#10] ;	X move (machine coordinate)
N130 G91 G28 Z0. ;	Z reference
G90 G53 G0 X#12 ;	X move (machine coordinate)
N140 G#14 G#15 M948 ;	Restores G codes in #14 and #15
#104 = #16 ;	Sets #104 = #16
N150 G91 G28 G0 Z0 ;	Z reference
G90 ;	Sets absolute mode
M99 ;	Return to parent program

8.2.6 Tool Registration Program - O5700

The tool registration program assigns PTN's (Program Tool Numbers) in the PTN column of the Custom side - TOOL DETAIL screen. PTN's are assigned to the POT# column corresponding to the tool location or magazine pot numbers. This program is typically executed as an initial setup step prior to running the part program.

The tool registration program assigns PTN's sequentially to the magazine starting with pot No. 1. Table 8-3 present an example program.

Operation Detail

1. For an empty tool pot, or a pot for which no tool number needs to be registered, specify “T00”.
2. If the number of tools registered is fewer than the number of pots, “T00” is automatically designated for the surplus pots.
3. An attempt to register more tools than the number of pots generates an alarm.
4. Specifying the same tool number more than once generates an alarm.

TABLE 8-3 TOOL REGISTRATION PROGRAM EXAMPLE

Program	Detail
O5700 ;	Program name
M57 ;	Activates Tool Number Register mode
T24 ;	Assigns PTN 24 to pot number 01
T93	Assigns PTN 93 to pot number 02
T65 ;	Assigns PTN 65 to pot number 03
T42 ;	Assigns PTN 42 to pot number 04
T77 ;	Assigns PTN 77 to pot number 05
… ;	Additional tool numbers specified for subsequent grippers
M30 ;	Deactivates Tool Number Register mode and ends program

To clear all assigned tool numbers, input and execute the following program (Table 8-4), in MDI mode.

TABLE 8-4 TOOL REGISTRATION CLEAR

Program	Detail
M57 ;	Activates Tool Number Register mode
T00 ;	All tool numbers specified for grippers are set to zero
M30 ;	Deactivates Tool Number Register mode and ends program

NOTES:

SKETCHES:

8.3 ATC Maintenance Mode and Screens

The Custom side provides MAINTENANCE screen pages to allow manual operation of the ATC mechanisms when performing maintenance or recovery procedures. These screens include:

- MAINTENANCE MENU - (initial MAINTENANCE screen) for activating and deactivating Maintenance mode.
- ATC MAINTENANCE - for operating the ATC shutter and activating the Stroke Extend mode.
- ATC MGZN MAINTE (Magazine Maintenance) - for magazine referencing and selecting different magazine positioning modes.

These screens are accessed from the Custom side - MAINTENANCE screen's MENU page.

- Operation of ATC maintenance functions can only be performed with Maintenance mode active.

When the Maintenance mode is On:

- Normal machine operation is inhibited
- ATC components displayed on the ATC MAINTENANCE and ATC MGZN MAINTE screens are operational (active).

When the Maintenance mode is Off:

- Normal machine operation is permitted
- ATC components displayed on the ATC MAINTENANCE and ATC MGZN MAINTE screens can only be viewed.

8.3.1 Maintenance Menu Page

To display the MAINTENANCE MENU page and turn Maintenance mode On or Off:

1. Press the [CUSTOM] function key. Press the [PO] softkey, if the PO screen is not displayed.
2. Press [MS] to display the [MAINTENANCE] softkey.
3. Press the [MAINTENANCE] softkey
4. Press [MODE SELECT] to turn Maintenance mode On or Off.

Figure 8-3 shows the Custom side - MAINTENANCE MENU page.

The standard screen features are present; screen name [2], and page numbers [4]. At center top of the screen, MAINTENANCE MODE [3] is displayed if the Maintenance mode function is active.

The display area [1] indicates key maintenance conditions. When a condition is active it is highlighted and a description of the condition (cause) is displayed in the alarm area [5].

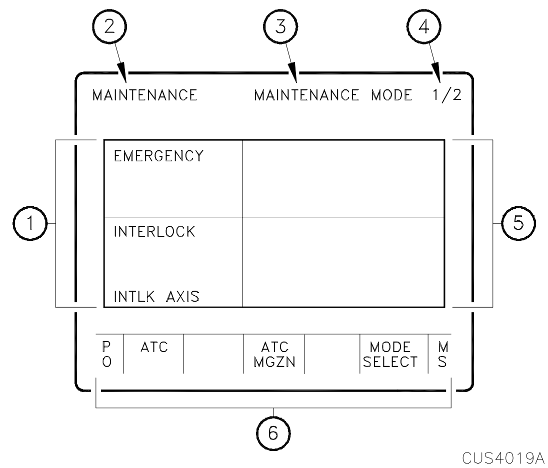


FIGURE 8-3 MAINTENANCE MENU PAGE

The softkey menus [6] provide access to the PO, ATC and ATC MGZN screens, the menu screen display [MS], and activation/deactivation of Maintenance mode [MODE SELECT].

8.3.2 ATC MAINTENANCE Screen

The ATC MAINTENANCE page allows operation of the ATC shutter and Stroke Extend mode, with Maintenance mode active.

To access the ATC MAINTENANCE page:

1. Display the MAINTENANCE MENU page - section 8.3.1.
2. Press [MODE SELECT], to activate Maintenance mode.
3. Press the [ATC] softkey.

Figure 8-4 shows the ATC MAINTENANCE page.

The standard screen features are present; screen name [4], and page numbers [7]. At center top of the screen, MAINTENANCE MODE [6] is displayed if the Maintenance mode is active.

Current status is indicated by STROKE NORMAL/STROKE EXTEND [3] indicating if stroke extend is active and SINGLE/JOG MODE [5] indicating the active operating mode.

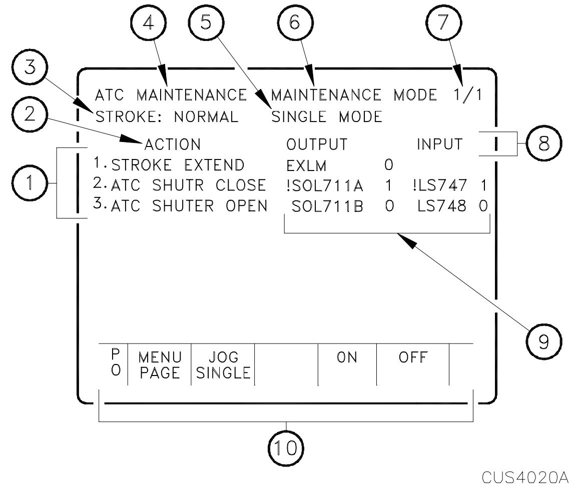


FIGURE 8-4 ATC MAINTENANCE PAGE

The ACTION area [2] lists the allowed operation steps [1] and include:

1. STROKE EXTEND - Extends the X axis stroke (travel) allowing spindle to enter the ATC zone. The ATC shutter must be open **before** Stroke Extend can be turned On.
2. ATC SHUTR CLOSE - Closes the ATC shutter when highlighted and the [ON] softkey is pressed.
3. ATC SHUTER OPEN - Opens the ATC shutter when highlighted and the [ON] softkey is pressed.

The OUTPUT INPUT area [8] shows the output device that initiates the action and its status [9] (On=1/Off=0). The input devise and status are also shown.

The softkey menus [10] provide access to the PO and MENU PAGE screens.

[JOG/SINGLE] - toggles between the JOG or SINGLE mode.

- In SINGLE (highlighted), operation is completed when the [ON] softkey is pressed.
- In JOG (highlighted) operation can be jogged by pressing and releasing the [ON] softkey.

[ON] - Activates the output, executing operation of the selected action.

[OFF] - Deactivates the output, halting operation of the selected action.

8.3.3 ATC MGZN MAINTE Screen

The ATC MGZN MAINTE (Magazine Maintenance) page allow tool magazine operation for referencing and setup of magazine positioning modes, with Maintenance mode active.

To access the ATC MGZN MAINTE page:

1. Display the maintenance menu screen - section 8.3.1.
2. Press [MODE SELECT] to activate Maintenance mode.
3. Press the [ATC MGZN] softkey.

Figure 8-5 shows the ATC MGZN MAINTE screen.

The standard screen features are present; screen name [3], and page numbers [6]. At center top of the screen, MAINTENANCE MODE [5] is displayed if the Maintenance mode is active.

FEED OVER RIDE area [1] sets the magazine indexing rate when executing FEED MODE [2] operations. FEED MODE [2] selects the magazine positioning mode. The AXIS SELECT area [4] displays the magazines PMC axis name (this field can not be changed).

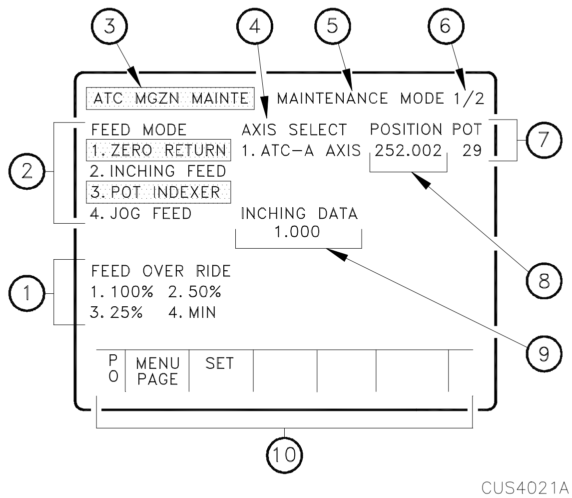


FIGURE 8-5 ATC MGZN PAGE

The POT [7] and POSITION [8] areas shows the ready position pot number and angular position from reference. INCHING DATA [9] sets the magazine rotation amount (in degrees) for INCHING FEED mode.

The softkey menus [10] provide access to the PO and MENU PAGE screens.

[SET] - activates the highlighted (white) feature selected in the FEED MODE and FEED OVER RIDE fields.

Feed Mode and Feed Over Ride

The FEED MODE and FEED OVER RIDE fields are used for magazine positioning operations.

FEED MODE and FEED OVER RIDE conditions are selected with the cursor keys and activated with the [SET] softkey. The active features are displayed in blue.

Table 8-5 lists the FEED OVER RIDE percentages to speed.

TABLE 8-5 FEED OVER RIDE RATES

1. 100%	9000 m/min
2. 50%	4500 m/min
3. 25%	2250 m/min
4. MIN	900 m/min

To execute magazine positioning operations, use the [CW] and [CCW] buttons, on the ATC Operation Panel.

FEED MODE operations include:

1. ZERO RETURN – Manually references the tool magazine (6th axis). Press and hold the [CW] button until the magazine reaches the reference position.
   - The maximum FEED OVER RIDE rate for reference is 50%
2. INCHING FEED – Sets continuous magazine rotation, at the selected FEED OVER RIDE rate.
3. POT INDEXER – Indexes the magazine one pot position, at the selected FEED OVER RIDE rate.
4. JOG FEED – Indexes the magazine by the distance set in the INCHING DATA field, at the selected FEED OVER RIDE rate.

8.4 ATC Recovery

The following recovery procedures are for resuming normal operation, if the machine stopped during a tool change cycle.

- ATC recovery depends on where the machine is in the tool change cycle. See section 8.4.1 and section 8.4.2.
- After recovery and before resuming normal operation, determine and correct the cause of the interruption.

Typical causes for interrupted machine operation and ATC status when operation was interrupted, include:

Emergency Stop - Typical Causes

- E-Stop button is pressed
- An axis in OT2 hard overtravel
- Thermal relay tripped
- CNC, spindle drive, or servo drive fault

ATC/Machine Status - in an E-Stop condition

- All axes motion is stopped
- Spindle orientation command is cancelled
- Spindle is clamped (**Y01.0 = 0**)
- ATC shutter solenoids go neutral, preventing shutter movement SOL711A (**Y05.5 = 0**) and SOL711B (**Y05.6 = 0**)
- CNC is RESET
- X axis Stroke Extend mode turns Off (**EXLM - 507.6 = 0**)

CNC or PMC Alarm - Typical Causes

- CNC Alarm - programming, operation, or CNC hardware failure
- PMC Alarm - programming, operation, or machine hardware (limit switch, solenoid valve, pressure switch, etc.) failure

ATC/Machine Status - in an Alarm condition

- All axes motion is stopped
- Spindle clamp state “held”
- ATC shutter state is “held”
- CNC is RESET
- X axis Stroke Extend turns Off (**EXLM - 507.6 = 0**)

8.4.1 Spindle Clamped on Tool in Magazine

In this condition:

- Spindle is clamped on tool in magazine
- ATC shutter is open (SOL711A - Output = 1)
- Stroke Extend mode is On (EXLM - Output = 1)
  - Confirm conditions on the ATC MAINTENANCE screen, section 8.3.2.

1. Determine and correct the condition causing the machine to stop.
2. Display the Custom side MAINTENANCE screen, section 8.3.1:
3. Activate Maintenance mode and display the ATC MAINTENANCE screen:
   A. Press [MODE SELECT].
   B. Press [ATC].
4. Set ATC shutter to open:
   A. Using the cursor keys, highlight ATC SHUTER OPEN.
   B. Press the [ON] softkey.
5. Turn the Stroke Extend mode On:
   A. Using the cursor keys, highlight STROKE EXTEND.
   B. Press the [ON] softkey.
6. Display the ACTUAL POSITION (ALL) screen:
   A. Press the [POS] function key.
   B. Press the [ALL] softkey.
7. Select HANDLE mode.
8. Using the MPG move +X to a machine coordinate of less than X–900mm (X–35.0").
9. Press [RESET] to clear the "501 OVER TRAVEL: –X" CNC alarm.
10. On the ATC MAINTENANCE screen
    A. Close the ATC shutter.
    B. Turn the Stroke Extend mode Off.
    C. Turn the Maintenance mode Off.
11. Perform Reference Return for all axes.
12. Confirm correct spindle tool data (on Custom - TOOL DETAIL screen).
13. Resume operation.

8.4.2 Spindle at Magazine and Not Clamped on Tool

In this condition:

- Spindle is in the magazine area, NOT clamped on a tool
- ATC shutter is open (SOL711A - Output = 1)
- Stroke Extend mode is On (EXLM - Output = 1)
  - Confirm conditions on the ATC MAINTENANCE screen, section 8.3.2.

1. Determine and correct the condition causing the machine to stop.
2. Display the Custom side MAINTENANCE screen, section 8.3.1.
3. Activate Maintenance mode and display the ATC MAINTENANCE screen:
   A. Press [MODE SELECT].
   B. Press [ATC].
4. Turn the Stroke Extend mode On:
   A. Using the cursor keys, highlight STROKE EXTEND.
   B. Press the [ON] softkey.
5. Display the ACTUAL POSITION (ALL) screen:
   A. Press the [POS] function key.
   B. Press the [ALL] softkey.
6. Select HANDLE mode.
7. Using the MPG move +Z so spindle clears tool holder retention knob.
8. Using the MPG move +X to a machine coordinate of less than X–900mm (X–35.0").
9. Press [RESET] to clear the "501 OVER TRAVEL: –X" CNC alarm.
10. On the ATC MAINTENANCE screen
    A. Close the ATC shutter.
    B. Turn the Stroke Extend mode Off.
    C. Turn the Maintenance mode Off.
11. Perform Reference Return for all axes.
12. Confirm correct spindle tool data (on Custom - TOOL DETAIL screen).
13. Resume operation.

8.5 Magazine Gripper Assemblies

The A25 tool magazine contains 25 sets of gripper assemblies, called pots (Figure 8-6).

Each finger set is mounted to the magazine [1] using two #40 pins [3] attached by M5x25 screws [5].

The pins [3] serve as pivot points for the fingers [2] and [8]. A captive spring [4] maintains the fingers in a gripping (closed) state.

A key [7] is mounted to the magazine [1], between each finger set, to align the gripper fingers. Each orientation drive key is mounted with one M5x22 screw [6].

The finger curvature matches the tool holder flange. Tool holders are held in the fingers by spring force and gripper-to-holder flange contact of approximately 195°.

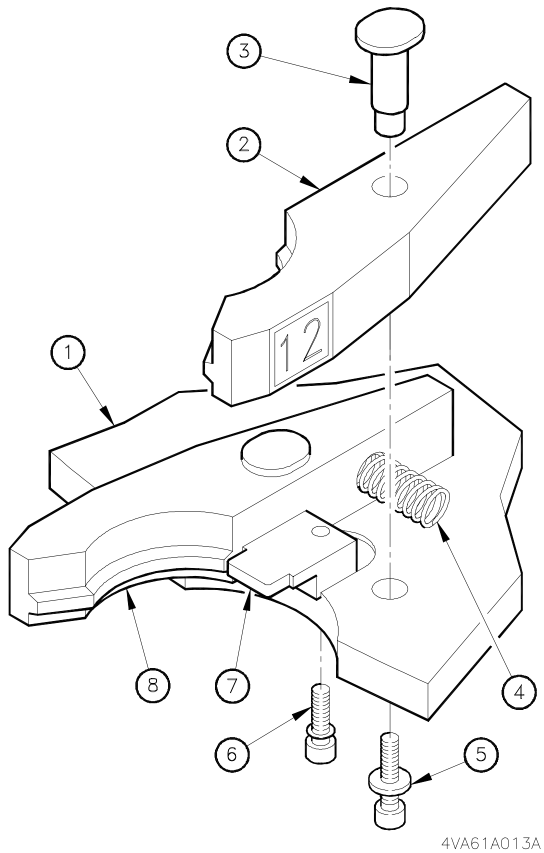


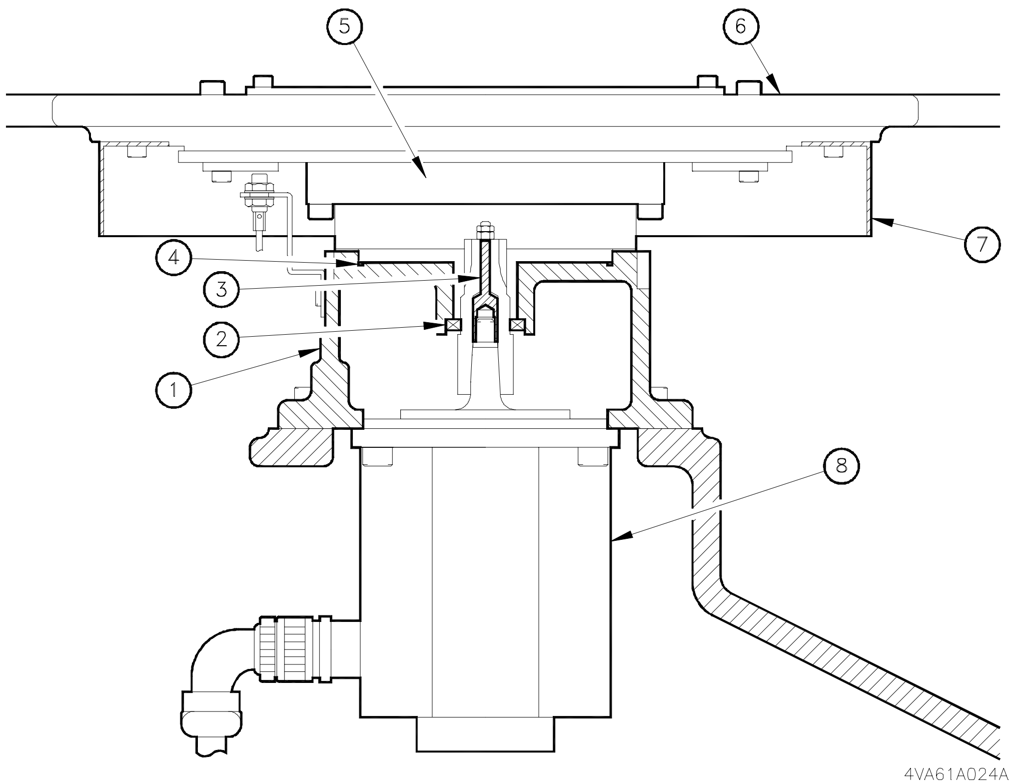
FIGURE 8-6 GRIPPER ASSEMBLY

8.6 Magazine Driving Components

The A25 magazine driving components are: mechanical, electrical, and electronic devices. The servo motor is controlled by the servo drive system, which sends commands and receives feedback signals from the CNC position control circuit.

8.6.1 Mechanical Components

The mechanical components and construction of the magazine are shown in Figure 8-7. The gear reduction ratio reduces servo motor rpm to a speed suitable for magazine indexing.



Legend

[1]	Gear Housing	[5]	Drum Gear
[2]	Oil Seal	[6]	Magazine Wheel
[3]	Servo Motor Gear	[7]	Cover
[4]	O-ring	[8]	Servo Motor

FIGURE 8-7 MAGAZINE MECHANICAL CONSTRUCTION

8.6.1.1 Electrical Components

The main electrical component of the A25 servo system is the Fanuc α E Series servo motor. This servo motor includes such features as:

- Large frame of reduced motor length.
- Drip proof construction complying with IP55 Standard.
- Precise positioning provided by an 8,192 pulse/revolution absolute position coder.

The indexing motor is a αE6/2000 Model, type A06B-0106-B578, equipped with a tapered shaft, and an αA8B Model absolute position coder. This is a 0.9 kW (1.2 hp), 2000 1/min. (rpm) motor, see Table 8-6 for additional motor specifications.

TABLE 8-6 A25 SERVO MOTOR SPECIFICATIONS

Item	Specification	
Motor Model	αE6/2000	
Output	0.9 kW	(1.2 hp)
Rated Torque at Stall	6.0 Nm	(4.4 ft·lb)
Rated Output Speed	2000 1/min (rpm)	
Maximum Theoretical Torque †	32 Nm	(23.5 ft·lb)
Rotor Inertia	0.0039 kg m^2	(0.66) ft·lb)
Maximum Theoretical Acceleration	8000 rad/s^2	
Weight	8.5 kg	(19 lb)
† Actual maximum torque is restricted by the Servo Amplifier - Current Limit values.		

8.6.1.2 Electronic Assemblies

The A25 drive system electronic assemblies include one Power Supply Module (PSM) and one Servo Amplifier Module (SVM). These components are in the servo drive unit, located in the MTC (Machine Tool Cabinet).

- The PSM is shared with the X, Y, and Z Servo Amplifier Modules.

Power Supply Module (PSM)

The Fanuc PSM supplies power to the spindle and servo amplifier modules. The PSM converts the 3-phase AC input voltage to DC voltage.

The PSM is a: Model No. PSM-26, Type A06B-6082-H126.

The PSM contains its own protection and error detection functions. Two 7-segment displays, on the front of the PSM display an alarm number in the event of a PSM fault (Figure 8-8).

- See chapter 5 for details on the self-diagnostic displays and appendix A for detail on PSM alarms.

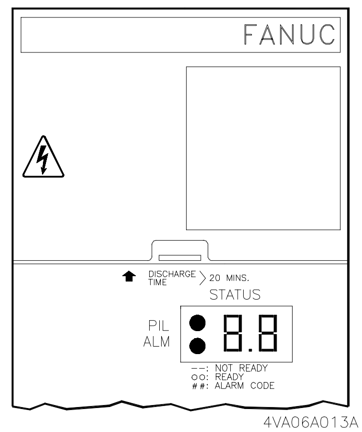


FIGURE 8-8 PSM SELF-DIAGNOSTIC DISPLAY

Table 8-7 lists the PSM-26 specifications.

TABLE 8-7 PSM-26 SPECIFICATIONS

Item		Specification
	Control Power	AC200V/230V - +10%, -15% Single-Phase - 50/60Hz ± 1Hz
Power Capacity	Main Circuit	37kVa
	Control Power	0.5kVa
Rated Output		26kW
Maximum Output		40KW
Control Method		Regenerative Control (Power Supply Regeneration)
Ambient Temperature		0° to 55° C (32° to 130° F)

8.6.1.3 Servo Amplifier Module – SVM

The A25 is equipped with a Fanuc SVM to control the AC servo motor by using a PWM (Pulse Width Modulation) inverter to regulate the DC power converted by the PSM.

The SVM is a: Model No. SVM1-20, Type A06B-6079-H102.

The SVM contains its own protection and error detection functions. A 7-segment display, on the front of the SVM, displays an alarm number in the event of a SVM fault.

See chapter 5 for details on the self-diagnostic displays and appendix A for detail on SVM alarms.

Table 8-8 lists SVM1-20 specifications.

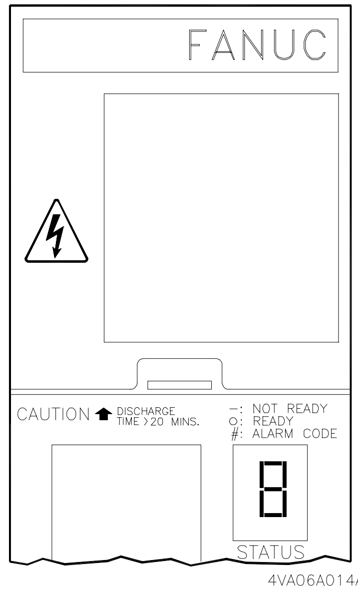


FIGURE 8-9 SVM SELF-DIAGNOSTIC DISPLAY

TABLE 8-8 SVM1-20 SPECIFICATIONS

Item	Specification
Rated Output Current	5.8A rms
Nominal Current Limit	20A (peak)
Main Circuit Control Method	Sine-wave PWM Control with Transistor (IGBT) Bridge
Feedback Method	Absolute, High-Resolution Position Coder
Alarm & Protection Functions	Low voltage alarm for control power Low voltage alarm for DC Link Overcurrent alarm IPM (Intelligent Power Module) alarm Fan alarm
Motor Application	α20/3000 and α30/3000
Ambient Temperature	0° C to 55° C (32° F to 130° F)

1. The rated output is guaranteed only at the rated input voltage. If the input voltage varies, the rated output may not be obtained even when the variation is within the allowable range.
2. The current limit (peak value) is a standard value. It varies by about ±10% depending on the circuit constraints.

8.7 ATC - Limit Switches

The A25 uses both limit and proximity (prox) switches for feedback signals to the PMC.

- One limit switch on the ATC door is used for the safety interlock
- Two prox switches on the ATC shutter to signal open and closed conditions
- One prox switch confirms if tool exists in the magazine
- One prox switch for magazine reference slow down.

Figure 8-10 shows the magazine mounted legend plate showing the general location of the ATC limit switches and solenoid valves.

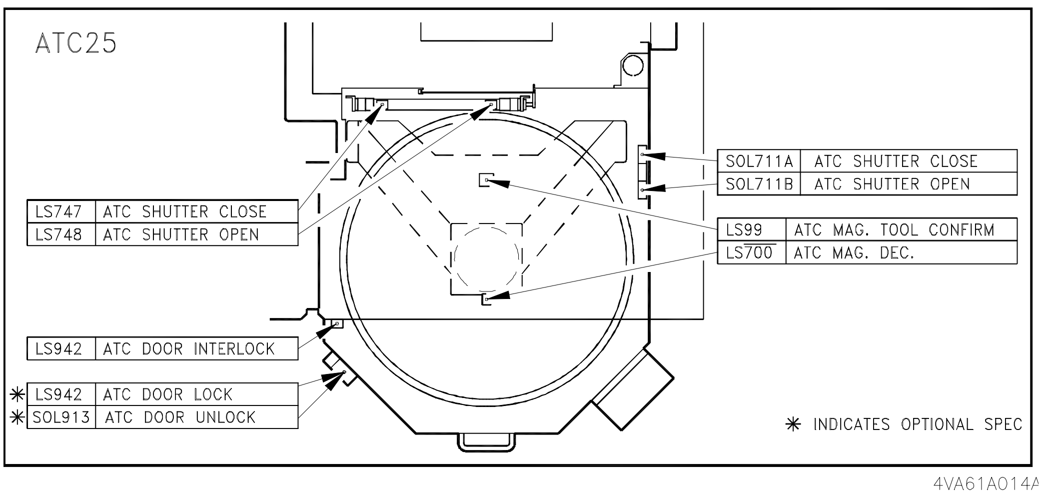


FIGURE 8-10 A25 LIMIT SWITCH GENERAL LOCATION

8.7.1 ATC Door Limit Switch - LS942

The ATC door is equipped with a safety interlock limit switch [1], wired into the E-Stop circuit. The machine enters an E-Stop condition if the ATC door is opened without first placing the ATC in the Manual Interrupt mode.

LS942 (Figure 8-11) is a plunger type switch actuated by the ATC door. Switch symbol, PMC address, and signal name is;

- LS942 (**X03.2**), ATC DOOR INTERLOCK

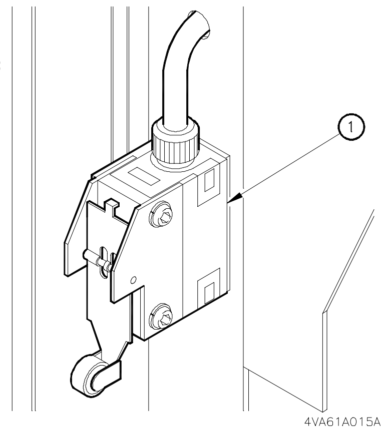


FIGURE 8-11 LIMIT SWITCH LS942

LS942 Adjustment

This switch is non-adjustable, if malfunctioning replace the switch.

LS942 Replacement

1. Press [CONTROL POWER OFF], to turn the machine Off and perform Lockout/Tagout at the facility (machine) power supply.
2. Remove the ATC magazine joint box cover. Six (M4x8) cross-head screws.
   - The joint box is the ATC Operation Panel (next to the ATC door).
3. Disconnect the switch wires from terminal strip TB1; C24HTC (#11), L942A (#12), and L942B (#13).
4. Pull the wires to the old switch and remove the switch [1] from its mounting bracket. Two (M4x22) screws.
5. If the new switch wires are not numbered, determine the proper wires and transfer the wire numbers from the old switch to the new switch.
6. Mount the new switch and pull its wires to the ATC magazine joint box.
7. Connect the switch wires.
8. Replace the ATC magazine joint box cover.

Testing LS942 Operation:

Perform the following checks to confirm proper switch operation.

1. Display the Custom - DIAGNOSTIC screen:
   A. Press the [CUSTOM] key. Press [PO] if PO screen is not displayed.
   B. Press [MS] to display the DIAGNOSE menu.
2. Press the [DIAGNOSE] softkey.Search PMC address X03.2. Key-in ’3’ and press [NO. SEARCH].
3. Close the ATC door.
4. Verify switch status (**X03.2 =1**), indicating ATC door closed.
5. Open the ATC door.
6. Verify switch status (**X03.2 =0**), indicating ATC door open.
7. Close the ATC door.
8. Manually reference all axes.
9. Select the MDI mode and key-in the following data:
   A. G20 G01 G91 X-10.0 F5.0 S100 M03
   B. Press [EOB] and [INSERT].
10. Press Cycle [START].
11. Open the ATC door with [MANUAL INTERRUPT] Off.
    - An E-Stop condition should be generated.
12. Press [RESET] to clear the alarm.
13. Manually reference all axes.
14. Select the MDI mode and key-in the following data:
    A. G20 G01 G91 X-10.0 F5.0 S100 M03
    B. Press [EOB] and [INSERT].
15. Press Cycle [START].
16. Press [MANUAL INTERRUPT], to turn it On
17. Open the ATC door.
    - The machine should continue cycle, without interruption.
18. If the machine functions as stated in Steps 4, 6, 11, and 17, the switch is wired correctly and functioning properly.

NOTES:

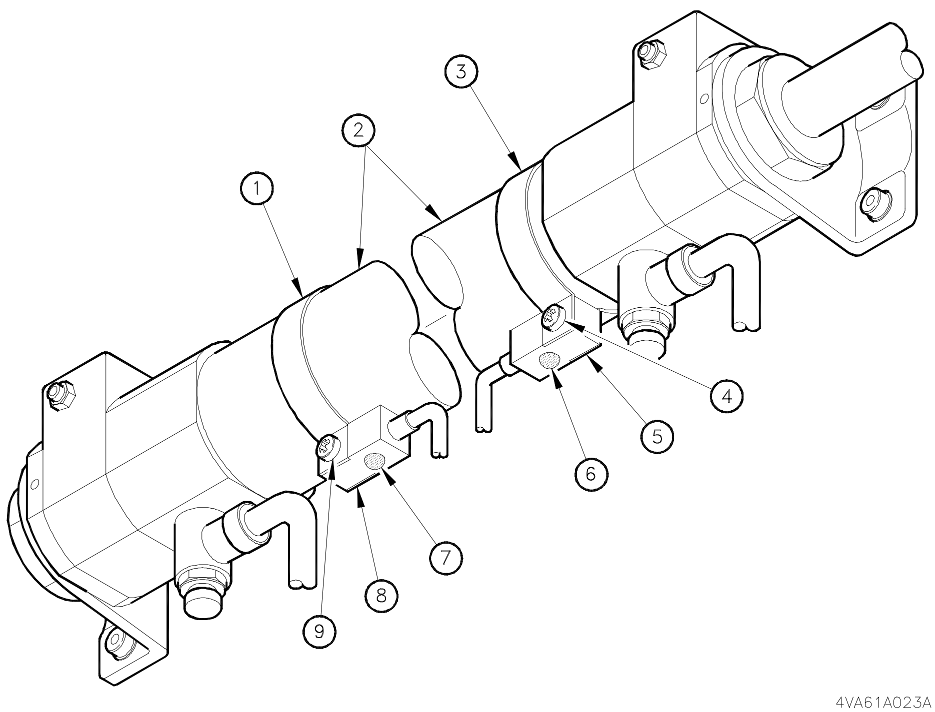
SKETCHES:

8.7.2 ATC Shutter Limit Switches - LS747 and LS748

The ATC shutter has two reed type prox switches mounted to the shutter air cylinder [2] (Figure 8-12) and confirm shutter closed and opened status. These switches actuate by sensing the presence of the cylinder piston through the cylinder body. Switch symbols, PMC addresses, and signal names are:

- LS747 (**X01.1**), ATC SHUTTER CLOSE
- LS748 (**X01.2**), ATC SHUTTER OPEN

The spindle is inhibited from moving to tool change position unless the shutter is open, confirmed by LS748 [5] and resuming the machining cycle inhibited unless the shutter is closed, confirmed by LS747 [8]. LS747 and LS748 are attached to each end of the shutter cylinder body by mounting straps [1] and [3].



Legend

[1]	Mounting Strap	[6]	LED
[2]	Air Cylinder	[7]	LED
[3]	Mounting Strap	[8]	LS747 (Close)
[4]	Screw	[9]	Screw
[5]	LS748 (Open)		

FIGURE 8-12 LIMIT SWITCHES LS747 AND LS748

Testing LS747 and LS748 Operation

Confirm switch operation, before adjusting or replacing either switch. If a switch is malfunctioning, adjust it as described in LS747 and LS748 Adjustment (pg 8-32). If adjustment fails to correct switch operation, replace it as described in LS747 and LS748 Replacement (pg 8-33).

Table 8-9 lists the correct status of LS747 and LS748 when the ATC shutter is open and closed.

TABLE 8-9 LS747 AND LS748 INPUT STATUS

Condition	Limit Switch	Diagnostic Status
ATC Shutter Closed	LS747	X01.1 = 1
	LS748	X01.2 = 0
ATC Shutter Open	LS748	X01.2 = 1
	LS747	X01.1 = 0

To test operation:

1. Display the Custom - MAINTENANCE MENU page, section 8.3.1.
2. Activate Maintenance mode and display the ATC MAINTENANCE screen:
   A. Press [MODE SELECT].
   B. Press [ATC].
3. Close the ATC shutter.
   A. Using the cursor keys, highlight ATC SHUTR CLOSE.
   B. Press the [ON] softkey.
4. Display the Custom - DIAGNOSTIC screen:
   A. Press the [PO] softkey.
   B. Press the [DIAGNOSE] softkey.
5. Search PMC address X01.1 (address X01.2 is also displayed). Key-in '1' and press [NO. SEARCH].
6. Verify status of inputs X01.1 and X01.2, see Table 8-9.
7. Display the ATC MAGAZINE screen.
8. Open the ATC shutter by:
   A. Using the [CURSOR] keys, highlight ATC SHUTER OPEN.
   B. Press the [ON] softkey.
9. Display the Custom - DIAGNOSTIC screen:
10. Verify status of inputs X01.2 and X01.1, see Table 8-9.

LS747 and LS748 Adjustment

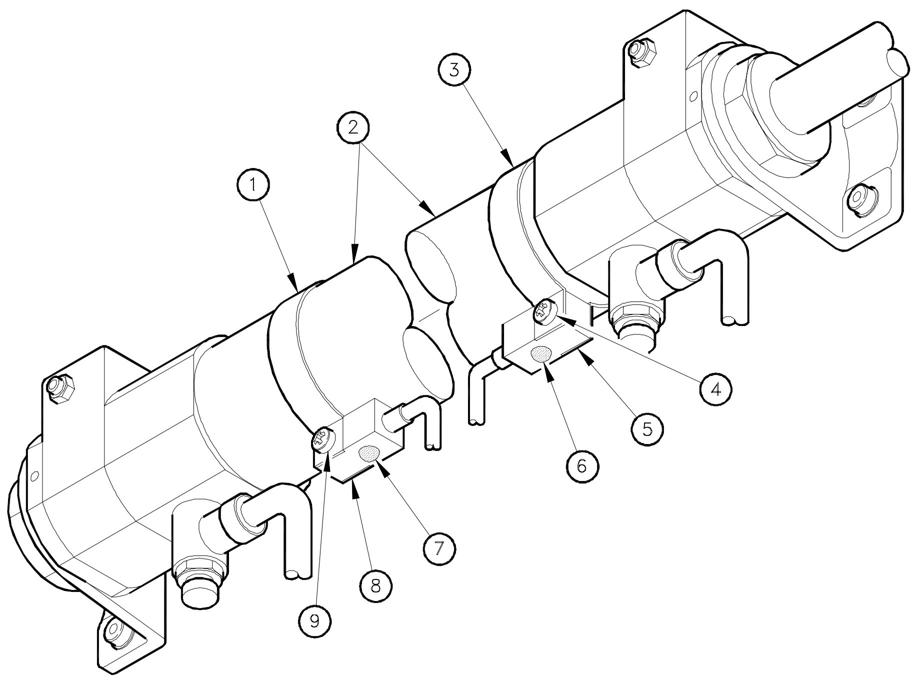
Adjustment of LS747 and LS748 is performed by loosening the mounting strap and sliding the switch along the cylinder until the switch actuates.

The objective in switch adjustment is to have LS747 actuated when the ATC shutter is closed and LS748 actuated when the ATC shutter is open.

Access to these switches is limited, but adjustments can be made by:

1. Removing the sheet metal cover to the left of the S/G (Splash Guard) door; this provides the easiest access.
2. Working through the ATC door; in this case avoid contact with magazine tools.

Confirm switch actuation by viewing the switch signal status, see Table 8-9 (pg. 8-31), or the On/Off status of the switch LED (actuated = LED On).



Legend

[1]	Mounting Strap	[6]	LED
[2]	Air Cylinder	[7]	LED
[3]	Mounting Strap	[8]	LS747 (Close)
[4]	Screw	[9]	Screw
[5]	LS748 (Open)		

FIGURE 8-13 LS747 AND LS748 REPLACEMENT

LS747 and LS748 Replacement

1. Press [CONTROL POWER OFF], turn the Main Power switch Off, and perform Lockout/Tagout at the facility (machine) power supply.
2. Remove the necessary covers to access the switches, see LS747 and LS748 Adjustment.
3. Remove the ATC magazine joint box cover. Six (M4x8) cross-head screws.
   - The joint box is the ATC Operation Panel (next to the ATC door).
4. Disconnect the switch wires from terminal strip TB1.
   A. For LS747; C24H (#5) and L747 (#6)
   B. For LS748; C24H (#5) and L748 (#7)
5. Pull the wires to the old switch [5] or [8] and remove the switch from its mounting strap [3] or [1]. One (M4x30) cross-head screw and (M4) nut [4] or [9].
6. If the new switch wires are not numbered, determine the proper wires and transfer the wire numbers from the old to the new switch.
7. Install the new switch and pull its wires back to the joint box.
8. Connect the switch wires
9. Replace the joint box cover.
10. Test switch operation and adjust if necessary, see Testing LS747 and LS748 Operation (pg 8-31) and LS747 and LS748 Adjustment (pg 8-32).
11. Replace any covers removed to access the switches.

8.7.3 Magazine Tool Exists Prox Switch - LS99

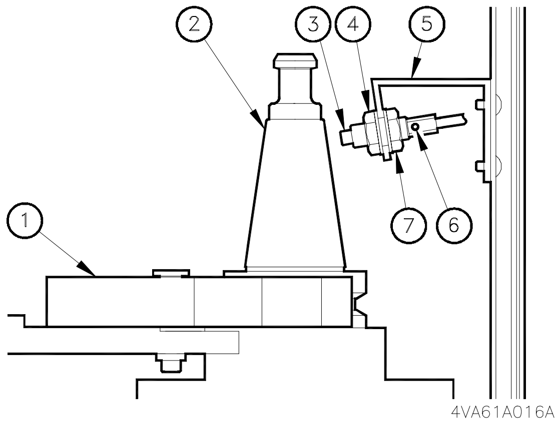
The ATC magazine uses one prox switch to confirm if a tool is present (exists) in the pot, at the ready position.

- If there are tools in the spindle and the pot at the ready position, the tool change is inhibited.

This prox switch [3] is actuated by sensing the presence of the tool holder shank [2].

Switch symbol, PMC address, and signal name is:

- LS99 (**X01.0**), MAGAZINE SIDE TOOL EXISTS CONFIRM



Legend

[1]	Tool Magazine	[5]	Bracket
[2]	Tool Holder	[6]	Led
[3]	LS99	[7]	Lock Nut
[4]	Lock Nut		

FIGURE 8-14 LIMIT SWITCH LS99

Testing LS99 Operation

Confirm operation of LS99 before replacing the switch. If switch is malfunctioning replace it, as described in LS99 Replacement (pg 8-35).

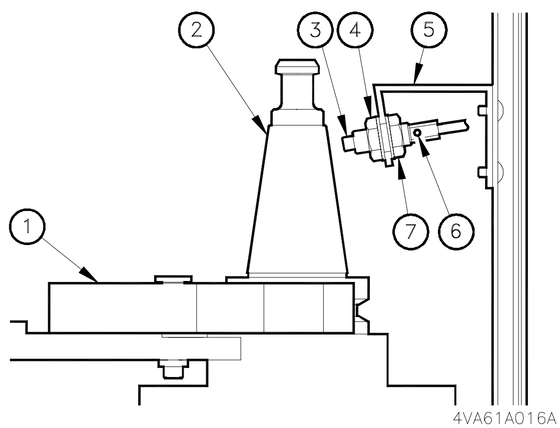
1. Press [MANUAL INTERRUPT], on the ATC Operation Panel.
2. Using the [CW] or [CCW] button, index an empty pot to the ready position.
3. Display the Custom - DIAGNOSTIC screen:
   A. Press the [CUSTOM] key. Press [PO] if PO screen is not displayed.
   B. Press [MS] to display the DIAGNOSE menu.
   C. Press the [DIAGNOSE] softkey.
4. Search PMC address X01.0. Key-in ’1’ and press [NO. SEARCH].
5. Verify switch status to be high (**X01.0 = 1)**.
6. Using the [CW] or [CCW] button, index a pot with a tool to the ready position.
7. Verify switch status to be low (**X01.0 =0**).
8. Press [MANUAL INTERRUPT], deactivating Manual Interrupt.

LS99 Adjustment

LS99 is a proximity switch with a broad sensing range. This switch is non-adjustable and must be replaced if malfunctioning, see LS99 Replacement.

LS99 Replacement

1. Press [CONTROL POWER OFF], turn the Main Power switch Off, and perform Lockout/Tagout at the facility (machine) power supply.
2. Remove the sheet metal cover to the left of the S/G door for switch access. Six (M4x8) cross-head screws.
3. Remove the ATC magazine joint box cover. Six (M4x8) cross-head screws.
   - The joint box is the ATC Operation Panel (next to the ATC door).
4. Disconnect the switch wires from terminal strip TB1. C24H (#1) and L99 (#2)
5. Pull the wires to the old switch [3] and remove the switch from bracket [5] by removing lock nut [4] (Figure 8-15).
6. If the new switch wires are not numbered, determine the proper wires and transfer the wire numbers from the old switch to the new switch.
7. Install the new switch and pull its wires to the joint box.
8. mount switch to bracket [5]
9. Set a 1.5mm gap between the switch face and tool holder by adjusting lock nuts [4] and [7].
10. Connect the switch wires to terminal strip TB1.
11. Replace the joint box cover.
12. Test operation of the new switch, see Testing LS99 Operation (pg 8-34).
13. Replace the left front cover.



Legend

[1]	Tool Magazine	[5]	Bracket
[2]	Tool Holder	[6]	Led
[3]	LS99	[7]	Lock Nut
[4]	Lock Nut		

FIGURE 8-15 LS99 REPLACEMENT

8.7.4 Magazine Reference Slow Down - LS700

Magazine indexing is actually the 6th axis, in the MT system, and performed by a servo motor with a position coder with a reference position like other axes.

Unlike the machine axes, the magazine references automatically when the first T code is commanded.

Like any servo controlled axis, the magazine references to a position coder marker pulse, with its true “zero” defined by the 6th axis field of Grid Shift parameter 1850.

- Magazine reference (zero) defines the true ready position on the magazine.

LS700 [3] is actuated by a reference dog [2] mounted to the under side of the magazine [1].

Switch symbol, PMC address, and signal name is:

- LS700 (**X09.5**) *DEC6
  - LS700 is wired “normally closed” the PMC signal goes low (**X09.5 = 0**) when actuated.

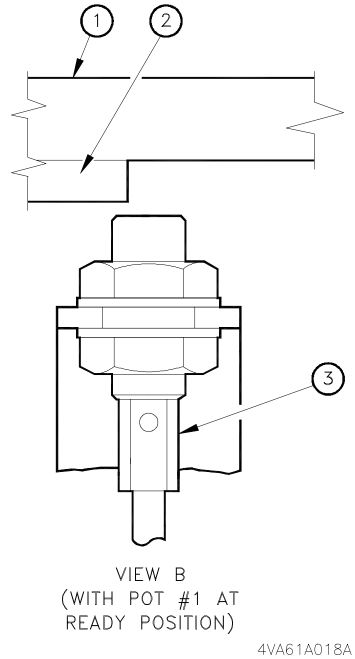


FIGURE 8-16 PROX SWITCH LS700

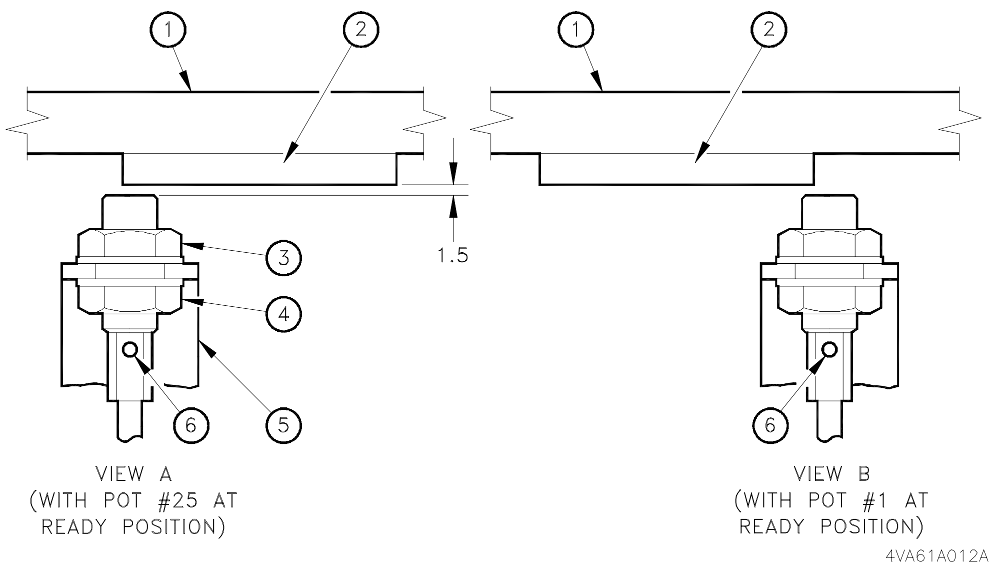
Testing LS700 Operation

Confirm operation of LS700 before adjusting or replacing the switch. If the switch is malfunctioning; adjust as described in LS700 Adjustment. If switch adjustment fails to correct a malfunctioning switch, replace it as described in LS700 Replacement.

Switch operation can be viewed by the status of its LED. When LS700 is on the reference dog, its LED is Off (**X09.5 = 0**). When LS700 is off the dog, its LED is On (**X09.5 = 1**).

Figure 8-17 shows the switch-to-dog relationship. With pot 25 at the ready position, reference dog [2] is over the leading edge of LS700 (**View A)**) the LED [6] should be Off (**X09.5 = 0**). With pot 1 at the ready position, reference dog [2] is over the trailing edge of LS700 (**View B**), the LED [6] should be On (**X09.5 = 1**).

1. Press [MANUAL INTERRUPT], on the ATC Operation Panel.
2. Using the [CW] button, index pot 25 to the ready position.
3. Verify that the switch LED is Off (**X09.5 = 0**).
4. Using the [CCW] button, index pot 1 to the ready position.
5. Verify that the switch LED is On (**X09.5 = 1**).
6. Press [MANUAL INTERRUPT], to deactivate Manual Interrupt.



Legend

[1]	Tool Magazine	[3]	Lock Nut	[5]	Bracket
[2]	Dog	[4]	Lock Nut	[6]	LED

FIGURE 8-17 LS700 LIMIT SWITCH-TO-DOG RELATIONSHIP

Switch Adjustment and replacement

Confirm switch operation (Testing LS700 Operation (pg 8-37)) before adjusting or replacing this switch. Changes to this switch setting may affect the magazine radial pot (ready position) alignment. Changes in ready position alignment may result in misoperation and damage to the ATC and spindle.

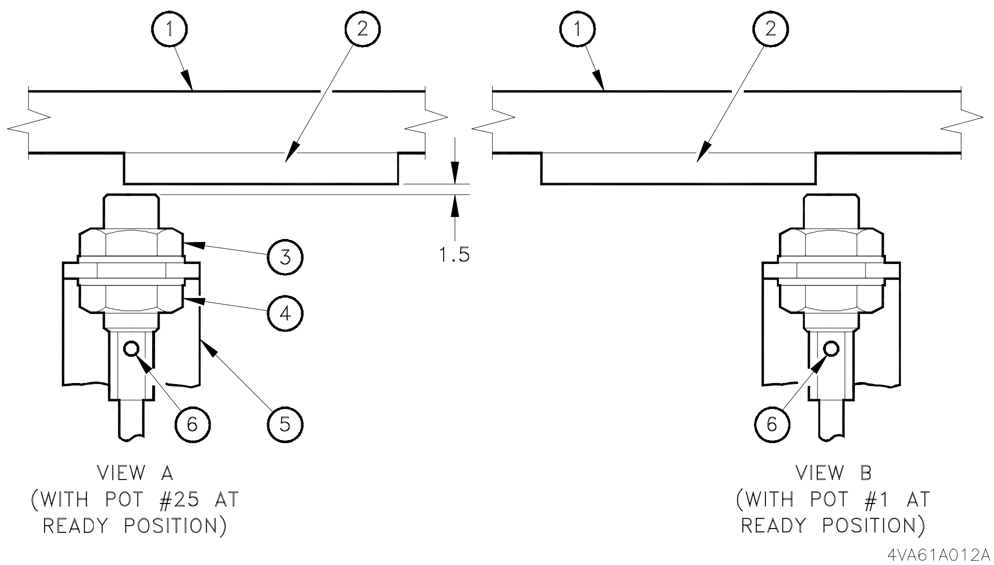
If LS700 is adjusted or replaced, see section 8.9.1 (pg 8-45) and check the magazine ready position alignment.

LS700 Adjustment

1. Press [MANUAL INTERRUPT], on the ATC Operation Panel.
2. Pressing the [CW] button, index pot 25 to the ready position (Figure 8-18 **View A**).
3. Loosen the two M12 lock nuts [3] and [4].
4. Back-off the upper lock nut [3], opening the switch-to-dog gap, until the switch LED [6] turns On.
5. Tighten upper lock nut [3], closing the switch-to-dog gap, until the switch LED [6] turns Off.
   - The gap should be approximately 1.5 mm. If less than 1.0mm, switch is weak and should be replaced.
6. Tighten lower lock nut [4] to secure the setting.
7. Using the [CCW] button, index pot 1 to the ready position (**View B**).
8. Verify that the switch LED [6] is On (**X09.5 = 1**).
   - If the LED is Off when pot 1 is at the ready position, the switch is set too close. Repeat Steps 3 through 6, to readjust the switch.
9. Check magazine ready position, see section 8.9.1 (pg 8-45).

LS700 Replacement

1. Using the [CW] or [CCW] button index pot 25 to the ready position.
2. Press [CONTROL POWER OFF], turn the Main Power switch Off, and perform Lockout/Tagout at the facility (machine) power supply.
3. Remove the ATC magazine joint box cover. Six (M4x8) cross-head screws.
   - The joint box is the ATC Operation Panel (next to the ATC door).
4. Disconnect the switch wires from terminal strip TB1 - C24H (#1) and *DEC6 (#4) and pull the wires to the switch.
5. Remove upper lock nut [3] and remove the switch from bracket [5].
6. Install the new switch and set the switch face-to-dog gap at 1.5mm (0.059") by adjusting lock nuts [3] and [4].
7. Pull the new switch wires to the joint box and connect.
8. Install the joint box cover.
9. Test operation of LS700, see Testing LS700 Operation (pg 8-37).
10. Adjust LS700, if necessary, see LS700 Adjustment (pg 8-38).
11. Check magazine ready position, see section 8.9.1 (pg 8-45).



Legend

[1]	Tool Magazine	[3]	Lock Nut	[5]	Bracket
[2]	Dog	[4]	Lock Nut	[6]	LED

FIGURE 8-18 LS700 ADJUSTMENT AND REPLACEMENT

8.8 ATC Shutter

The ATC shutter isolates the tool magazine from the machining area and is opened and closed upon commands from the PMC. Shutter positioning is by an air cylinder with both rate and cushioning adjustments. Limit switches are provided at both ends of the shutter stroke to confirm open and closed conditions, see section 8.7.2 for details.

All maintenance procedures described in this section are performed from the magazine side of the shutter. Access to shutter adjustments and lubrication is obtained by removing the sheet metal cover on the front of the machine, to the left of the rolling S/G (Splash Guard) door.

8.8.1 Shutter Alignment Adjustments

The ATC shutter is mounted to two guide blocks on a LM (Linear Motion) guide way. Two adjusting screws are provided on each guide block for aligning the shutter to its opening.

With the shutter closed, set the adjusting screws to obtain a uniform fit between the shutter and its mating sheet metal.

- Proper shutter alignment should provide maximum sealing without causing a binding condition during operation.

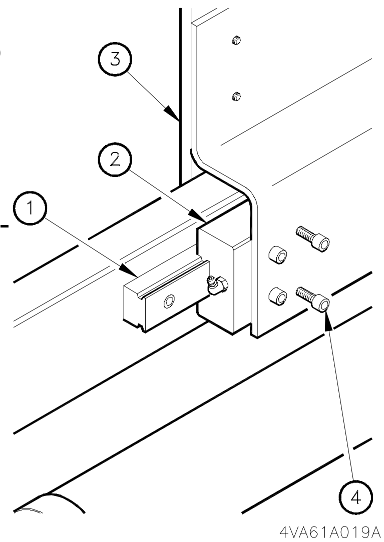


FIGURE 8-19 SHUTTER ALIGNMENT ADJUSTMENTS

8.8.1.1 Positioning Rate Adjustment

ATC shutter motion is driven by an air cylinder which is actuated by a double sided solenoid valve SOL711A /B (Figure 8-20). Flow control valves [3] and [4] are installed in the solenoid output air lines for adjusting the shutter opening and closing rates.

The left valve [4] is for SOL711A [1] and controls the shutter closing rate. The right valve [3] is for SOL711B [2] and controls the shutter opening rate.

The objective is to adjust the flow control valves to obtain the quickest positioning rates possible, with smooth operation.

- Flow adjustments may affect cylinder stroke end cushioning.
- The initial flow control valve settings are 1 to 1½ turns from closed.

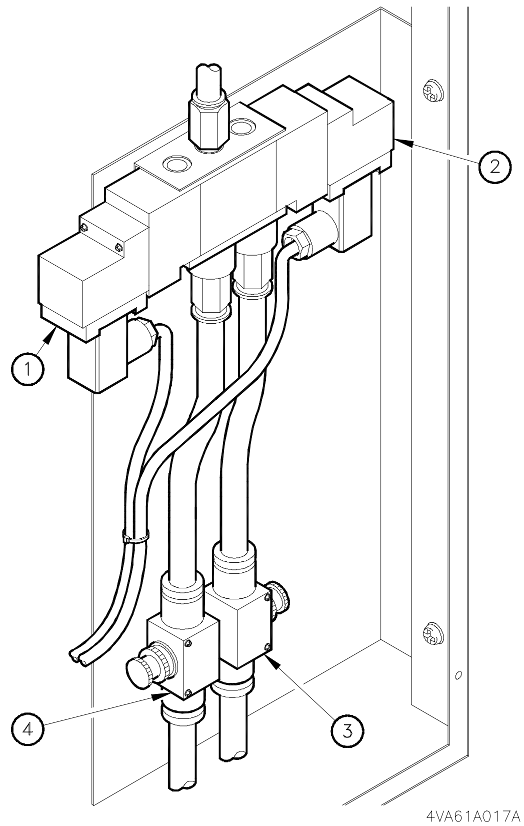


FIGURE 8-20 SHUTTER FLOW CONTROL AND SOLENOID VALVES

To Adjust the Positioning Rates:

1. Remove the sheet metal cover to the left of the S/G door for switch access. Six (M4x8) cross-head screws.
2. Observe shutter operation while opening and closing, using Maintenance mode, see section 8.3.
   A. Open the shutter; use the cursor keys to select ATC SHUTER OPEN and press the [ON] softkey.
   B. Close the shutter; use the cursor keys to select ATC SHUTR CLOSE and press the [ON] softkey.
3. If shutter operation appears slow, open the appropriate valve to increase the positioning rate.
4. Observe shutter operation. If the shutter stops abruptly, without a slow down, adjust the appropriate cushion, see section 8.8.1.
5. Install the sheet metal cover removed in Step 1.

8.8.1.2 Cylinder Cushion Adjustments

The ATC shutter air cylinder has cushion adjustments, on both ends of the cylinder, for adjusting the stopping rate at the end of each stroke.

The objective is to set these adjustments to obtain a slow down at the end of stroke and prevent hard stops when the shutter is opened and closed.

- The initial cushion adjustment settings are 1 to 1 ½ turns from closed.

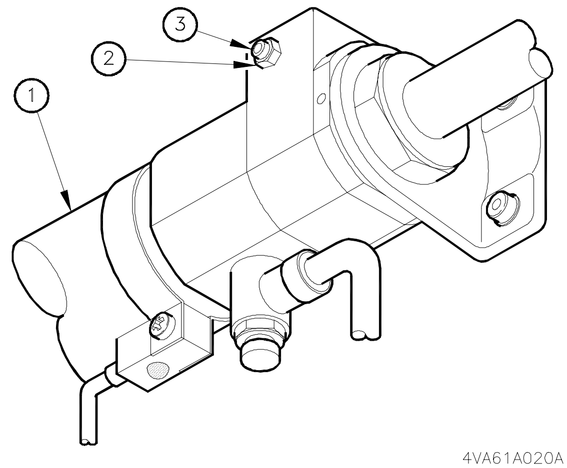


FIGURE 8-21 CYLINDER CUSHION ADJUSTMENTS

To Adjust Cushioning:

1. Remove the sheet metal cover to the left of the S/G door for switch access. Six (M4x8) cross-head screws.
2. Observe shutter operation while opening and closing, using Maintenance mode, see section 8.3.
   A. Open the shutter; use the cursor keys to select ATC SHUTER OPEN and press the [ON] softkey.
   B. Close the shutter; use the cursor keys to select ATC SHUTR CLOSE and press the [ON] softkey.
3. If shutter stops hard, adjust the appropriate cushion by.
   A. Loosen the adjusting screw jam nut [2].
   B. Turn the adjusting screw clockwise[3], closing the valve, to obtain more cushioning or counterclockwise to obtain less cushioning.
   C. Tighten the jam nut [2].
4. Open and close the shutter and observe its operation. Repeat Step 3, if further adjustment is necessary.
5. Install the S/G cover removed in Step 1.

8.8.2 Shutter Lubrication

The ATC shutter LM guide blocks are equipped with grease fittings for periodic lubrication.

The grease fittings are installed in the outer ends of each guide block and accessed by removing the cover left of the rolling S/G door.

- Lubricate each guide block with 3cc's of Kluber NBU 15 grease every 1000 hours of operation.
- When lubricating the guide blocks, activate the ATC Maintenance mode to enable shutter operation.

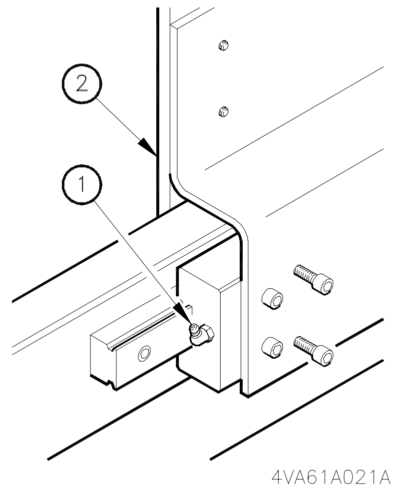


FIGURE 8-22 SHUTTER LUBRICATION POINTS

8.9 ATC Alignments

ATC alignments include: spindle orientation, the X and Z tool change positions, and the tool magazine ready position.

- Spindle orientation is described in chapter 6 of this Maintenance Guide.

This section describes how to check and set the:

- X tool change position
- Z tool change position
- Tool ready position

ATC alignments are affected by:

- Machine wrecks causing servo motor-to-axis coupling slippage
- Adjustments to an axis deceleration switch (*DECX, *DECZ, and *DEC6)
- Maintenance involving the servo motor-to-axis coupling (servo motor replacement, TAC bearing replacement, ball screw replacement, etc.)

X and Z Tool Change Positions

During ATC operations, the tool change program commands X and Z axes to move to their 2nd reference positions.

- The X axis 2nd reference position places the spindle over the tool pot, so that both centerlines are in-line, along the X axis plane.
- The Z axis 2nd reference position sets the Z axis at the proper height for placing tools in and out of the pot grippers.

X and Z axis 2nd reference positions are set in CNC parameter 1241 and are specific (machine coordinate) values measured from machine zero to the tool change position.

X Tool Change Position

When checking the X axis ATC position, any deviation between ATC position and the setting value of parameter 1241 indicates that machine zero has changed. Correct the X axis ATC position by resetting the location of machine zero, NOT by changing the setting of parameter 1241.

Tool Magazine Ready Position

The magazine ready position is the radial location placing the tool pot centerline in-line with the spindle centerline when the X axis is at its tool change position. This position is established by a setting value entered into the 6th axis field of Grid Shift parameter 1850.

8.9.1 Checking X Tool Change and Ready Position

This procedure verifies that the tool pot and spindle centerlines are in-line when X is at the tool change position and the magazine at the ready position. To achieve pot-to-spindle centerline alignment, positioning the magazine and X axis is necessary.

Correction to either of these alignments is made by changing the setting value of Grid Shift parameter 1850 for the affected axis.

- The X axis field of parameter 1850 sets the X tool change position by shifting machine zero.
- The 6^{th} axis field of parameter 1850 sets the magazine ready position

The objective of this procedure is to restore the machine to its original factory settings.

Before Starting this Procedure:

Set X 2^{nd} reference position parameter 1241 to its original setting, see the parameter listing supplied with the machine. If the original setting can not be determined, set the X 2^{nd} reference position to –1200.000.

Alignment Checking Procedure:

1. Cancel the “stored” reference positions.
   A. From a power Off condition, press [CONTROL POWER ON].
   B. During the control boot process, simultaneously press and hold the [P] and [CAN] keys.
2. Manually reference return the X, Y, and Z axes.
3. Set the control to Metric (G21).
   A. Select MDI mode.
   B. Key-in ’G21’.
   C. Press the [EOB] key.
   D. Press the [INSERT] key.
4. Ensure that the spindle can be rotated by hand. If not; select MDI, Key-in ’M05’, [EOB], press [INSERT], and press Cycle [START].

5. Reference the tool magazine, using Maintenance mode.
   A. Display the maintenance menu screen - section 8.3.1.
   B. Press [MODE SELECT] to activate Maintenance mode.
   C. Press the [ATC MGZN] softkey.
   D. Using the cursor keys, highlight ZERO RETURN.
   E. Press the [SET] softkey.
   F. Press and hold the ATC Operation Panel [CW] button until the magazine reaches its reference dog and aligns.
6. Mount an indicator in a tool holder and place it in the spindle.
7. Place a “test ring” into magazine pot 1.
   - If a test ring is not available, place an end mill holder, upside down, in pot 1. You can then tram the holders tool pocket I.D.
8. Display the ATC MAINTENANCE screen:
   A. Press the [MENU PAGE] softkey.
   B. Press the [ATC] softkey.
9. Open the ATC shutter.
   A. Using the cursor keys, highlight ATC SHUTER OPEN.
   B. Press the [ON] softkey.
10. Activate Stroke Extend mode.
   A. Using the cursor keys, highlight STROKE EXTEND.
   B. Press the [ON] softkey.
11. Display the ATC MGZN MAINTE screen.
   A. Press the [MENU PAGE] softkey.
   B. Press the [ATC MGZN] softkey.
12. Select the INCHING FEED mode and set the INCHING DATA:
   C. Using the cursor keys, highlight INCHING FEED.
   D. Press the [SET] softkey.
   E. Using the cursor keys, highlight INCHING DATA.
   F. Key-in the desired Inching Data amount and press the [INPUT] key, see section 8.3 for more detail.

13. Select Handle mode and use the MPG to;
    A. Position X to –1200.000mm (machine coordinate)
    B. Position Z (minus), placing the indicator inside the test ring.
14. Tram the test ring I.D. (rotating the spindle by hand).
15. Position the magazine, and X axis if necessary, to obtain a TIR (Total Indicator Reading) of 0.100mm (0.0039") or less.
    - Position the magazine with the [CW] or [CCW] buttons. The magazine moves at the Inching Feed Data distance, set in Step 12, each time the button is pressed.
    - Position X with the MPG.
16. Record the value displayed in the POSITION field of the ATC MGZN MAINTE screen.
    - This value is the magazine's rotated distance from reference (zero). This distance is the difference from current magazine zero to the true ATC ready position and is amount of change to be set in the 6th axis Grid Shift parameter 1850, see section 8.10 for detail.
17. View the machine coordinate display.
    A. Press the [POS] function key.
    B. Press the [ALL] softkey.
18. Record the X axis machine coordinate value.
    - The X value should be the same as the set value in the X 2nd reference position (parameter 1241). Any deviation between the two values is the amount of change to be set in the X axis Grid Shift parameter 1850, see section 8.10 for detail.
    - If a deviation greater than 1.500mm is found, other problems may exist. Contact your Makino service group.
19. Using the MPG, position:
    A. Z (plus), moving the indicator clear of the test ring.
    B. X (plus), into its normal operating range (right of the ATC shutter).
20. On the ATC MAINTENANCE page:
    A. Close the ATC shutter.
    B. Deactivate STROKE EXTEND mode.
21. Display the MAINTENANCE MENU page and deactivate Maintenance mode.

22. Input required changes to parameter 1850 (section 8.10).
23. After changing the parameter settings, power down the machine.
24. Cancel the “stored” reference positions.
    A. From a power Off condition, press [CONTROL POWER ON].
    B. During the control boot process, simultaneously press and hold the [P] and [CAN] keys.
25. Manually reference return the X, Y, and Z axes.
26. Reference the tool magazine, see Step 5.
27. Re-tram the test ring to verify the parameter changes are correct, repeat steps 6 through 24.

NOTES:

SKETCHES:

8.9.2 Z Axis - 2nd Reference Position Alignment

The Z 2nd reference position, parameter 1241, is used to establish the proper Z axis position (height) for placing tools in and out of the magazine. When properly set, this position allows for “tool knockout” during spindle unclamp.

The Z 2nd reference position setting value is a machine coordinate value measured from Z axis Machine Zero. The parameter setting may vary from machine to machine and must be checked by this procedure. Before starting this procedure, Z axis Machine Zero must be properly set, see chapter 7.

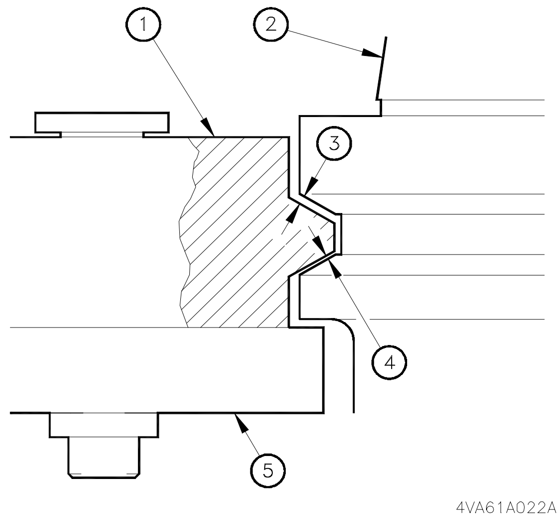


FIGURE 8-23 TOOL HOLDER FLANGE-TO-GRIPPER FINGER RELATIONSHIP

Figure 8-23 shows the proper tool holder [2] to gripper [1] relationship when Z is at its 2nd reference position. The tool holder flange should almost contact the bottom [4] of the gripper curvature leaving clearance at the top [3] of the curvature to prevent magazine [5] deflection during spindle unclamp.

1. Cancel the “stored” reference positions.
   A. From a power Off condition, press [CONTROL POWER ON].
   B. During the control boot process, simultaneously press and hold the [P] and [CAN] keys.
2. Perform a manual reference return operation for the X, Y, and Z axes.
3. Set the control to Metric (G21).
   A. Select MDI mode.
   B. Key-in ’G21’.
   C. Press the [EOB] key.
   D. Press the [INSERT] key.
4. Ensure that the spindle can be rotated by hand. If not; select MDI, Key-in ’M05’, [EOB], press [INSERT], and press Cycle [START].

5. Manually load a tool holder into the spindle.
6. Select MDI and position Z axis to its 2nd reference position.
   A. Key-in ’G30 G91 Z0’.
   B. Press the [EOB] key.
   C. Press the [INSERT] key.
   D. Press Cycle [START].
7. Origin (set to zero) the relative coordinate display.
   A. Press the [POS] function key.
   B. Press the [REL] softkey.
   C. Press the [ORIGIN] then [ALL EXEC].
8. Reference the tool magazine, using Maintenance mode.
   A. Display the MAINTENANCE MENU screen - section 8.3.1.
   B. Press [MODE SELECT] to activate Maintenance mode.
   C. Press the [ATC MGZN] softkey.
   D. Using the cursor keys, highlight ZERO RETURN.
   E. Press the [SET] softkey.
   F. Press and hold the ATC Operation Panel [CW] button until the magazine reaches its reference dog and aligns.
9. Display the ATC MAINTENANCE screen:
   A. Press the [MENU PAGE] softkey.
   B. Press the [ATC] softkey.
10. Open the ATC shutter.
    A. Using the cursor keys, highlight ATC SHUTER OPEN.
    B. Press the [ON] softkey.
11. Activate Stroke Extend mode.
    A. Using the cursor keys, highlight STROKE EXTEND.
    B. Press the [ON] softkey.
12. Select Handle mode and use the MPG to position X axis, close to the magazine. **Do not** engage the gripper fingers in this step.

Be Alert

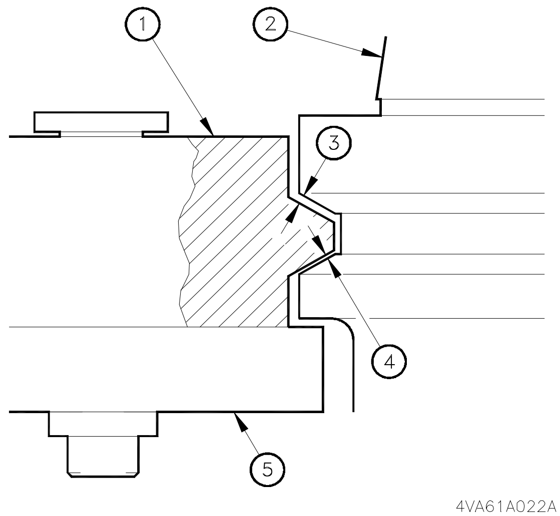
CAUTION

Machine movements are unprotected in this state. Set MPG to lowest feed setting. Stop axis motion immediately if tool holder-to-gripper finger interference or binding is noticed. Failure to follow this caution may result in machine damage.

13. Engage the tool holder with the gripper fingers, using the MPG to slowly move X minus.
14. Using the MPG, carefully move Z plus or minus to obtain proper clearance [3] and [4] between the tool holder flange and the bottom of the gripper fingers, as shown in Figure 8-24.
    - Only minimal clearance is necessary at the bottom gap. The objective is to avoid a Z height setting which results in deflecting the magazine when tools are loaded.

    C. Using the MPG, move +X, to normal operating range (right of ATC shutter).

    D. Select MDI (to prevent accidental MPG positioning).



Legend

[1] Gripper	[4] Bottom Gap
[2] Holder	[5] Magazine
[3] Top Gap	

FIGURE 8-24 TOOL HOLDER FLANGE-TO-GRIPPER FINGER RELATIONSHIP

15. View the relative coordinate display.
    A. Press the [POS] function key.
    B. Press the [REL] softkey.
16. Record the Z relative coordinates (include minus sign if displayed).
    - This Z relative coordinate is the amount (distance and direction) to be set in the Z 2nd reference position, parameter 1241.

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17. On the ATC MAINTENANCE page:
    A. Close the ATC shutter.
    B. Deactivate STROKE EXTEND mode.
18. Display the MAINTENANCE MENU page and deactivate Maintenance mode.
19. Enter the necessary change to parameter 1241, see section 8.10.
20. Input required changes to parameter 1850 (section 8.10).
21. After changing the parameter settings, power down the machine.
22. Power up the machine, to establish new parameter setting.
23. Repeat Steps 1 through 13 to verify settings.

8.10 Setting ATC Position Related CNC Parameters

The following ATC positions are defined by CNC parameters, as follows:

- X tool change position – X axis 2nd reference position parameter 1241 set relative to X machine zero. See chapter 8 for procedure to establish X machine zero.
- Z tool change position – Z axis 2nd reference position parameter 1241 set relative to Z machine zero. See chapter 8 for procedure to establish Z machine zero.
- Ready position – 6th axis Grid Shift parameter 1850.

Parameter Setting Values:

X axis 2nd - Reference Position parameter 1241

Unit of setting data: = 0.001mm

Parameter setting range: = ±99999999

Parameter setting value: = –1200000

Z axis 2nd - Reference Position parameter 1241

Unit of setting data: = 0.001mm

Parameter setting range: = ±99999999

Parameter setting value: = –190000 (± any deviation found in alignment checking procedure (section 8.9.2).

6th axis Grid Shift parameter 1850.

Unit of setting data: = Detection Unit, where one (1) detection unit equals 0.001 degree.

Parameter setting range: = 0 to ±99999999

Parameter setting value: = Grid shift amount in the 6th axis to provide magazine ready position.

The procedure in section 8.9.1 provides a “deviation amount” from the current Grid Shift parameter setting. Therefore, add or subtract the deviation amount from the current parameter setting.

8.10.1 CNC Parameter Setting Procedure

- The control provides the capability to “password” protect the CNC parameters. If this feature is active, the password must be known in order to activate the Parameter Write Enable function.

1. Activate PWE (Parameter Write Enable) to unlock CNC parameters.
   A. Select MDI mode.
   B. Press the [OFFSET SETTING] function key.
   C. Press the [SETING] softkey, to select the (SETTING HANDY) screen.
   D. Select the PARAMETER WRITE field.
   E. Key-in a ’1’ and press [INPUT].
2. Press the [SYSTEM] function key.
3. Key-in the required parameter number press the [NO. SRCH] softkey.
4. If the parameter has separate fields for the X, Y, and Z axes. Use the cursor keys to highlight the field to be set.
5. Key-in the parameter setting value and press the [INPUT] key.
6. Deactivate PWE, locking the parameters.
   A. Press the [OFFSET SETTING] function key.
   B. Press the [SETING] softkey, to select the (SETTING HANDY) screen.
   C. Select the PARAMETER WRITE field.
   D. Key-in a ’0’ and press [INPUT].
   E. Press the [RESET] key, to clear the alarm.
   F. Press the [CONTROL POWER OFF] button, to turn the control Off.

These CNC parameters require the control be turned Off and back On, before the parameter change takes effect.

8.10.2 X and Z Axes - Operating Range Related Parameters

When a change is made to a 2nd reference position parameter, the following CNC parameters must also be checked and, if necessary, reset as described below:

Parameter 1327 - Stored Stroke Limit 1 (Negative Direction)

This parameter sets the coordinate values of stored stroke limit 1 in the negative direction for each axis, in the machine coordinate system.

Setting range: ±99999999

Setting value: Value of 2nd reference position + (–0.200mm)

Parameter 6932 - Maximum Operating Range

This parameter is used to set the maximum operating range for the X axis, in the machine coordinate system.

Setting range: 0 to +99999999

Setting value: Value of 2nd reference position –1200000

An incorrect setting value in either of these parameters could result in an axis soft overtravel alarm when a tool change is commanded.

8.11 Periodic Maintenance

Check the following items, at the recommended frequencies, to ensure proper machine performance, accuracies, and capabilities, are and maintained, throughout its life.

8.11.1 Daily Checks

1. Thoroughly clean the shank of tool holders in the magazine.
   - Remove all chips, coolant residue, and oil from the tool holder shanks.
2. Clear any accumulation of chips beneath the tool magazine.
3. Clean the spindle taper with the Spindle Taper cleaning tool supplied with the machine.
4. At the end of each shift, clean chips and machining contaminates from all way covers.

- Do NOT use air to clean the axis way covers!

8.11.2 Semi-annual Checks

1. Grease the ATC shutter LM guides with Kluber NBU 15 grease, or equivalent:
   - Inject 3cc's of grease into each fitting, see section 8.8.2 for detail.
2. Check the ATC shutter alignment to ensure a uniform fit around its opening, see section 8.8.1 for detail.

8.11.3 Annual Checks:

1. Verify operation of all ATC limit switches, see section 8.7 for detail.

PM Schedule

This schedule is based on an 8 hour day, 40 hour week. Therefore one year is approximately 2,000 hours of operation.
See chapter 3 for more detail and information pertaining to PM and Lubrication of the machine tool components, recommended oils, greases, fill points, frequencies, etc.

NOTES:

SKETCHES:

Chapter 9 Oil Controller

4V81A Type

Daikin Model AKZ306-D41B

Makino V55 High-speed Vertical
Machining Center

MAKINO

Chapter 9
Oil Controller

Contents

9.1 Overview

The oil controller is a stand alone refrigeration unit and is one part of the complete oil controller/machine system used for cooling and lubrication of the spindle and other machine components. Spindle lubricant temperature is maintained within ±1° C (±2° F) of the machine bed temperature, by a bed mounted thermal couple and the OC.

Oil controller location (Figure 9-1) is on the right side of the machine behind the hydraulic and air cabinet [3]. The standard oil controller [2] is machine mounted and comes on machines with a 14,000 rpm spindle.

The 20,000 rpm spindle uses a second floor mounted unit [1], set directly behind the machine.

- The system uses Makino Spindle Lubricant, supplied from the tank next to the machine mounted oil controller.

Considerations for installation of second oil controller are provided in section 9.4.

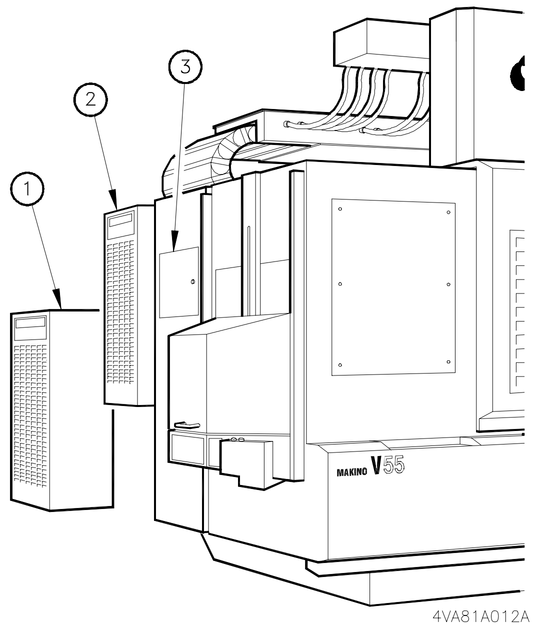


FIGURE 9-1 OIL CONTROLLER LOCATIONS

9.1.1 Safety Precautions

The oil controller uses R22 refrigerant. Avoid discharge of R22, and have only qualified personnel perform maintenance.

- Perform preventive maintenance tasks before operation.
- Never operate the controller without oil in the unit.
- Do not contact motor casing or refrigerant hose as they may get hot.
- In abnormal conditions, stop operation immediately to prevent damage, electrical shock, fire or injury.
- Do not operate with casing, terminal or other electrical shields or covers removed.
- To prevent possible coil burning or fire, do not perform continuous operation exceeding motor capacity.

9.2 The Oil Controller Unit

The oil controller(s) on the V55 are Model No. AKZ 306-D14B manufactured by Daikin Industries Ltd. These are self-contained refrigeration units connected to Makino supplied components consisting mainly of a pump/ tank unit and two machine mounted pumps.

Oil controller operation is controlled by PMC parameters and set up to cycle:

- Five seconds after machine power is turned On
- When the spindle is running
- 20 seconds after the spindle is stopped

An oil controller alarm or low oil level condition results in:

- A feed hold condition
- Axis interlocks turned On
- The spindle turned Off
- Coolant and spiral chip conveyor turned Off

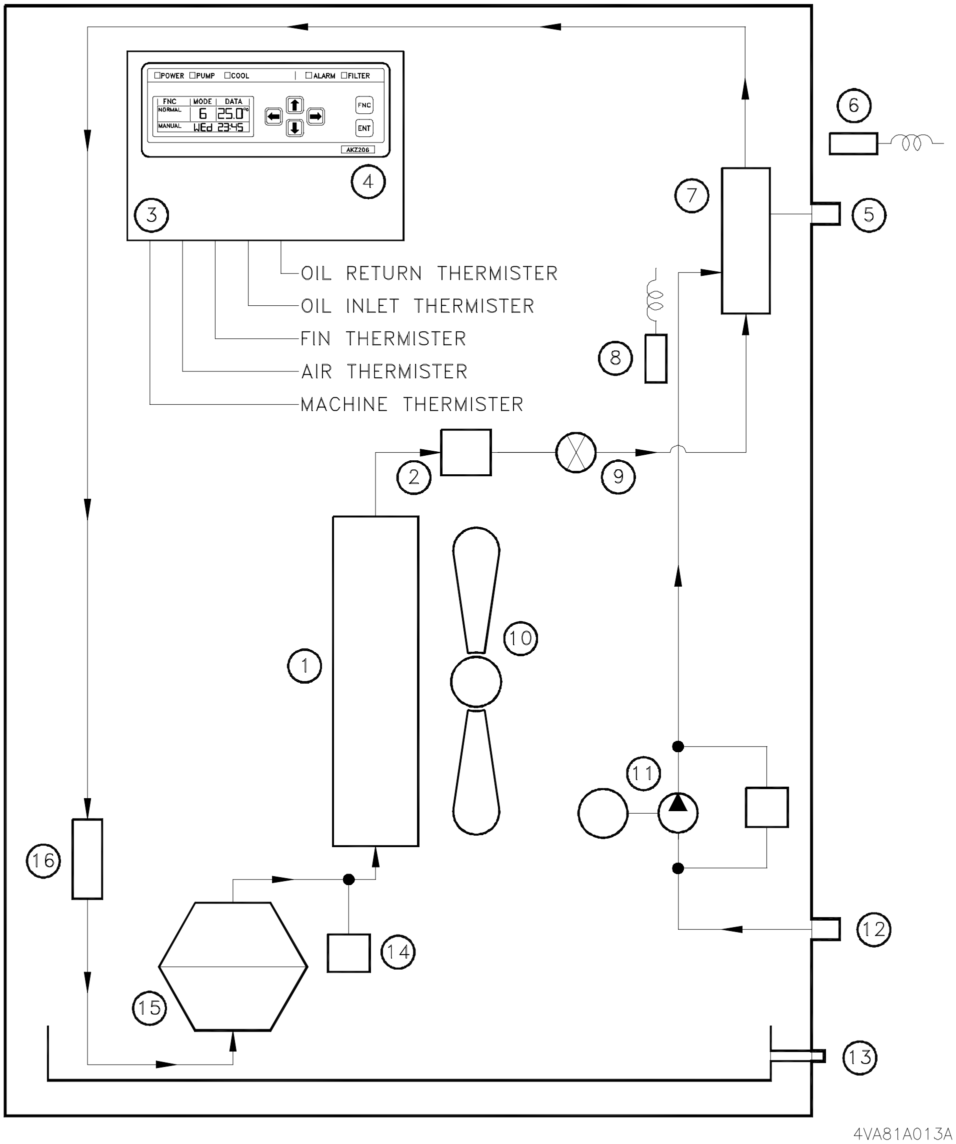
A block diagram showing the major oil controller components is presented in Figure 9-2.

Pump P1 [11] draws oil from the tank through the inlet [12] and sends it to the evaporator [7] where it is cooled to the setting determined by thermistors Th-4 [8] and Th-2 [6]. The cooled oil is then routed to the machine through outlet port [5].

Refrigerant R22 is processed within the unit by compressor [15] and condenser [1]. Evaporator [7] is a heat exchanger where the oil is cooled.

Oil Controller Type Change - April 1998

This chapter discusses the Type ’B’ Model AKZ 206-D41Daikin Oil Controller placed on machine built after April 1998.
Machines built before April 1998 used a Type ’A’ Model AKZ 206-D41Daikin Oil Controller. Though basic operating principles are the same, specific operation and parameter details differ. Contact your Makino service group for details on this unit.



Legend

[1]	Condenser Unit	[9]	Expansion Valve
[2]	Filter	[10]	Fan
[3]	Temperature Controller	[11]	Oil Pump (P1) With Relief Valve
[4]	Operation Panel	[12]	Oil Inlet Port
[5]	Oil Outlet Port	[13]	Oil Pan With Drain Port
[6]	Oil Return Thermistor (Th-2)	[14]	High Pressure Switch
[7]	Evaporator	[15]	Compressor And Motor
[8]	Oil Inlet Thermistor (Th-4)	[16]	Accumulator

FIGURE 9-2 OIL CONTROLLER UNIT BLOCK DIAGRAM

9.2.1 Oil Controller Specifications

TABLE 9-1 OIL CONTROLLER SPECIFICATIONS

Item		Specification	Detail
Manufacturer		Daikin Industries Ltd.	
Model		AKZ306-D41B	
Cooling Capacity [50/60 Hz]		8000/9000kW (6800/7700kcal/hr)	
Power Source [50/60 Hz]	Capacity	200V-9.7kVa/220V-10.3kVa	
	Main Circuit	3Φ 200/200 – 220V	
	Operation Circuit	1Φ 24VAC	
Dimensions (HxWxD)		1220 x 560 x 620mm	
Weight		150kg	
Compressor [50/60 Hz]		RCC1x70CT (3Φ200/200-220V) (2.2kW, 2P)	Hermetic Rotary/ Daikin
Fan	Fan	P45E11S	Propeller
	Motor 150W	EEOQ-T	Y-E Drive
Oil Pump [50/60 Hz]	Motor	KSP-MHS20-DB-75EM	Kuse
	Capacity	30.9/37.0 L/min.	Trochoid
Pump Pressure	Suction	20.0kPa	
	Discharge	0.20Mpa	
Oil Temp. Control		Temp. Difference Type (±10° C)	Mode 6 (0° Set)
Refrigerant		R22	1.8kg
Refrigerator Oil		SUNISO	4GS-D1, 1.1L
Operating Range	Room Temp.	5 to 40° C	
	Oil Inlet Temp.	5 to 40° C	
	Oil Viscosity	1.6 - 200mm^2/s	
Connection Piping Size		Rc 1¼″ (Female)	Oil Inlet
		Rc 1¼″ (Female)	Oil Outlet
		Rc 3/8″ (Female)	Oil Pan Drain
Transformer		3P000966-1(200/24V)	Tamura Seisakusho
Non-fuse Breaker		NF30-CS(30A)	Mitsubishi Electric

NOTES:

SKETCHES:

9.2.2 Oil Controller Electrical Schematic

Figure 9-3 shows the oil controller electrical drawings for use in troubleshooting, see section 9.7.

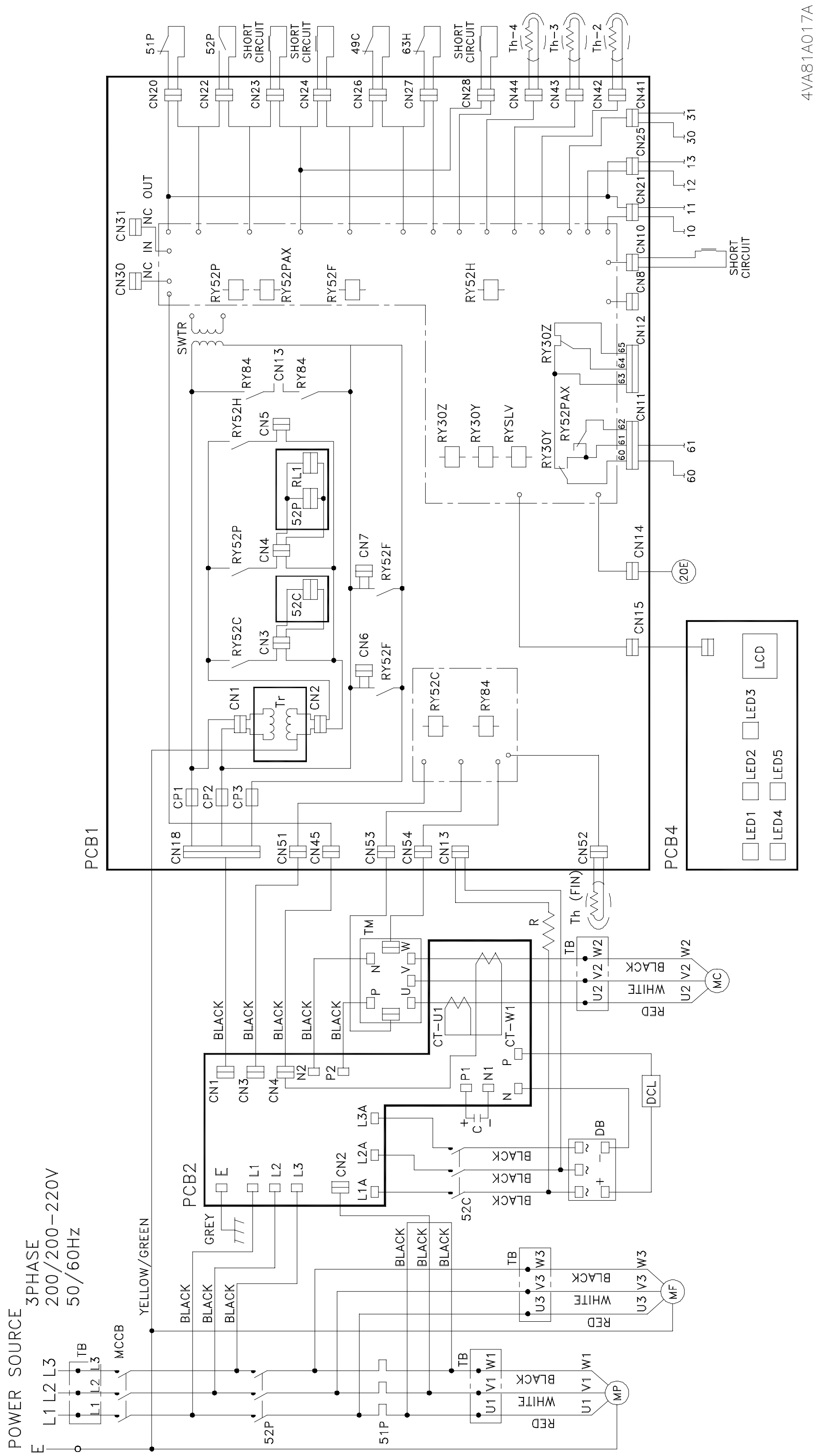


FIGURE 9-3 OIL CONTROLLER ELECTRICAL DRAWINGS

9.3 Oil Controller/Machine System

The oil controller/machine system includes:

- The oil controller with compressor and pump (P1), see section 9.2
- Two external, machine-mounted pumps (P2 and P3)
- Oil tank with pump (P4)
- Machine mounted sensor to monitor temperature of the bed casting

This system cools the:

- Spindle unit and lubricate the spindle bearings
- X, Y, and Z axis ball screw cores
- X, Y, and Z axis TAC bearings and lubricates the TAC bearings
- Y axis ball screw casting
- Machine column by lines in the front and back column covers

Figure 9-4 shows a block diagram of the oil controller/machine system.

General System Description

A general description of the lubrication/cooling system follows. For specific information see the Spindle and Feed Axis chapters of this Maintenance Guide.

Pump P1 - mounted in the oil controller, draws oil from the tank and supplies oil to the spindle head.

Pump P2 - mounted vertically on the back of the saddle, pulls oil from the spindle stator area and returns it to the tank.

Pump P3 - mounted on an angle on the back of the saddle, draws oil from the spindle rotor area returns it to the spindle.

Pump P4 - mounted on the tank, circulates oil through the center of the ball screw and TAC bearings of each axis, the cooling covers on the front and back of the column, and the Y-axis ball screw casting.

Spindle bearing lubrication is performed by a method referred to as “under race lubrication”. Patented by Makino, this method of lubrication jets oil through orifices in the side of the spindle into the under side of the bearing races.

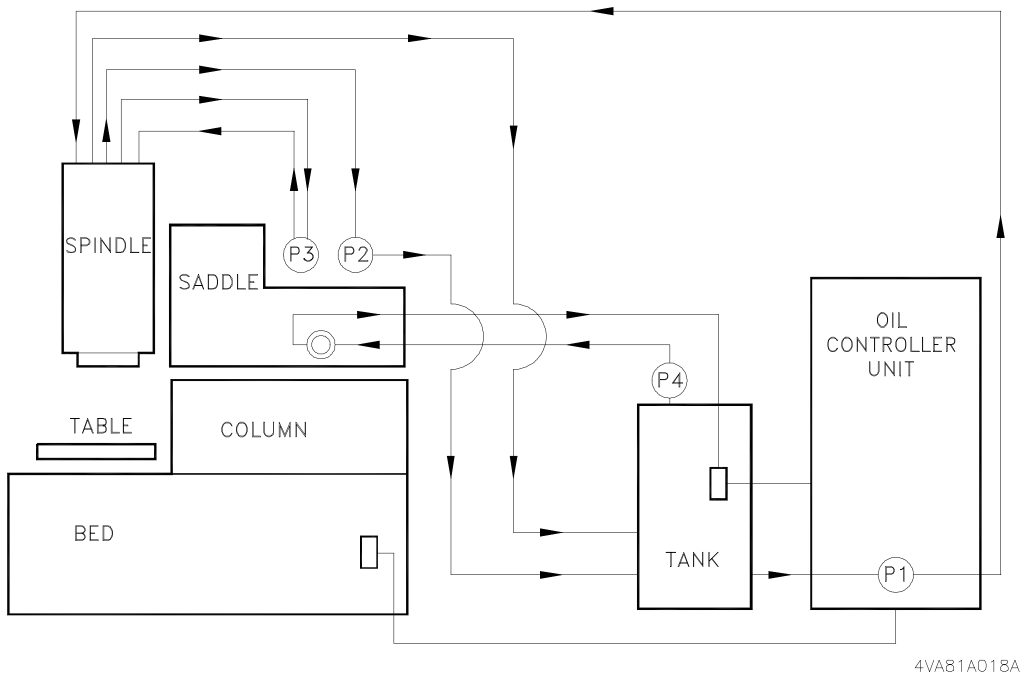


FIGURE 9-4 OIL CONTROLLER/MACHINE SYSTEM

9.4 Second Oil Controller Unit Installation

Install the second unit based on the following considerations:

- Clear of interference to/from an optional lift up chip conveyor
- On a solid and flat surface
- Away from direct sunlight and other heat sources
- Near good ventilation and little humidity
- Where discharged air will not be drawn in
- Convenient for wiring and plumbing
- Where there is minimal dust, dirt, oil mist, etc.

9.4.1 Second Oil Controller Unit Precautions

In addition to the safety precautions in section 9.1.1 (pg 9-1):

- Secure ground terminals tightly
- Do not run unit with casing removed
- Do not operate the main unit during test operations

9.4.2 Power Source and Connections

Power Source Capacity:

3-phase 200V - 9.7kVa or 3-phase 220V - 10.3kVa

Connections:

Power to the second oil controller is supplied from the MTC (Machine Tool Cabinet). At machine installation, connection was made as follows:

- Power supply cable type - 600V PVC insulated wire of $2mm^2$, minimum
- MTC side connections made at circuit breaker CB2 - terminals L1, L2, and L3.
- oil controller side connections made at - terminal block TB - terminals L1, L2, and L3, located in the switch box. Removal of oil controller casing is required to access the switch box and its cover.
- Electrical phase was checked when power was first applied. An out-of-phase condition is indicated by oil controller alarm **U1**.

9.4.3 Remote Control and Alarm Connections

Oil controller operation is remotely controlled by the PMC including response to specific PMC alarms generated by machine mounted feedback devices.

Oil controller side connections for these functions are made at - terminal block TeS1, located in the switch box. TeS1 is shown in Figure 9-5.

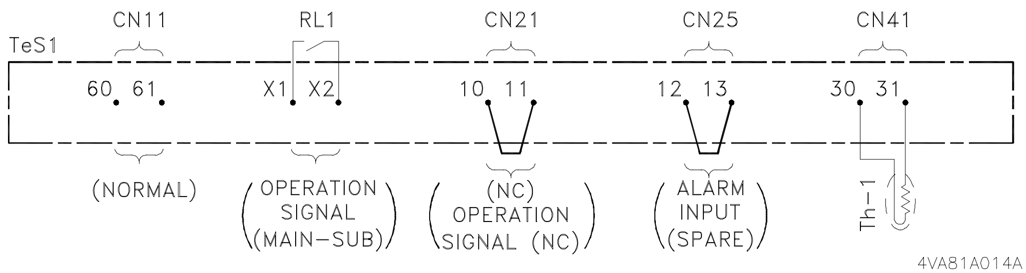


FIGURE 9-5 REMOTE CONTROL AND ALARM CONNECTIONS

- Manufacturer installed, short circuit wire between terminals 10 and 11 was removed
- Wire MIT1 connected to terminal 10 - for “NC (PMC) Ready” signal
- Wire MIT2 connected to terminal 11 - for spindle oil temperature controller thermal alarm “THOL1” signal (**X11.1**)
- Wire C24H connected to terminal 60 - for spindle oil temperature controller flow switch “LS170” signal (**X02.1**)
- Wire OMAL connected to terminal 61 - for spindle oil temperature controller clogged detection “LS173” signal (**X02.0**)

9.5 Operation Panel Description

The Oil Controller Operation Panel (Figure 9-6) is located at the top right of the oil controller.

A description of the operation panel devices follows:

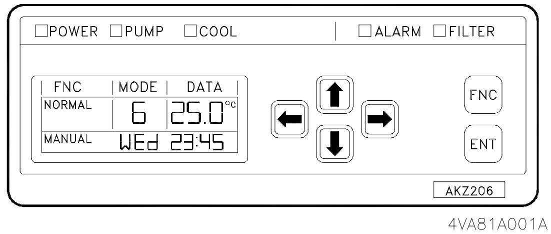


FIGURE 9-6 OIL CONTROLLER OPERATION PANEL

9.5.1 LED Indicators

The five LED indicators, located across the top of the operation panel, indicate the general operating conditions of the unit, as described in Table 9-2.

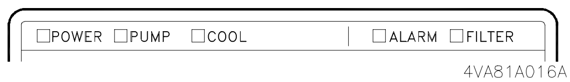


TABLE 9-2 LED INDICATOR DETAIL

LED Name	Color	Indication
POWER	Green	On when +5V is applied to controller.
PUMP	Green	On when pump is running.
COOL	Green	On when compressor is running.
ALARM	Red	On for LEVEL 2 abnormality, Flashes for LEVEL 1. Buzzer sounds for both.
FILTER	Yellow	Flashes to warn that filter is clogged or parameter set operating time is exceeded. Press the [ENT] to turn Off.

9.5.2 LCD Displays

The LCD's display the seven oil controller functions, associated modes, and data. The data type is identified at right of the data with unit of measure (°C, K (Kilocalorie), % or Hz). The LCD display is detailed in Table 9-3.

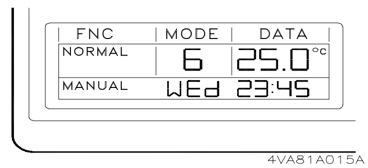


TABLE 9-3 LCD DISPLAY DETAIL

LCD Display	Content
FNC	Displays the seven different oil controller functions.
MODE	Displays the modes associated with each function.
DATA	Displays data for the selected function and mode.
TIMER	Displays whether timer is On or Off and On/Off setting time.

9.5.3 Keys

The keys, on the operation panel allow viewing, selecting, setting and storing the oil controller functions and function modes.

Keys are detailed in Table 9-4.

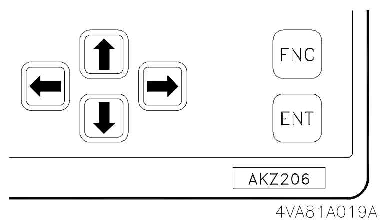


TABLE 9-4 KEY DETAIL

Key	Operation
[FNC]	Press to step through the seven oil controller functions. Press to cancel data, in the DATA display area, before pressing the [ENT] key.
[ENT]	Press to store data currently shown in the DATA display area.
[↑]	Press to step through the different modes of the oil controller functions. The selected mode is shown in the MODE display area.
[↓]	
[→]	Press to change the data shown in the DATA display area.
[←]	

9.6 Oil Controller Functions and Modes

Oil controller functions and modes are described below. Where applicable, data setting values, or ranges are provided. This information is included for *Troubleshooting Purposes Only*.

Do NOT Change Any Oil Controller Data

CAUTION

The data setting values are specific to the V55. The values have been determined, and factory set, to maintain the oil at the proper temperature and minimize thermal growth of the machine components lubricated and cooled by this system.

9.6.1 Oil Controller Functions

The oil controller has seven operating functions, listed in Table 9-5. The active function is shown in the FNC display area.

- Two function names, SETTING and MONITOR, are used twice. The active function is determined by whether the name is On (steady) or Flashing.

TABLE 9-5 OIL CONTROLLER FUNCTIONS

Function (FNC Display)	Purpose	Description
LOCK (Flashing)	Locks operation panel	Prohibits all key operations except lock cancel and pump motor operation.
NORMAL (ON)	Normal operating function	Displays modes (0 - 9) and their current setting values.
SETTING (ON)	Data setting	Sets or changes setting values of the NORMAL function modes (0 - 9).
MONITOR (ON)	Monitoring values	Displays the current status of: temperatures, inverter frequency, and percent of direct cooling capacity.
TIMER (ON)	Timer setting	Changes AUTO or MANUAL setting timer and set time in MANUAL. This mode **MUST BE** set to **MANUAL**.
SETTING (Flashing)	Parameter setting	Sets oil controller parameters for operation.
MONITOR (Flashing)	Service monitor	Displays oil controller alarm codes and levels.

9.6.2 Oil Controller Modes

The oil controller operating functions have different modes and associated data. The active mode is shown in the MODE display area.

CAUTION

Do NOT Change Any Oil Controller Data

The data setting values are specific to the V55. The values have been determined, and factory set, to maintain the oil at the proper temperature and minimize thermal growth of the machine components lubricated and cooled by this system.

- The V55 uses specific oil controller functions and modes. Only those functions and modes applicable to the V55 are discussed below.
- Modes not used by the V55 may have oil controller “default settings” which should not be changed.

LOCK

The LOCK function locks or unlocks the Oil Controller Operation Panel. This Function has no specific modes. Its activation is indicated by LOCK flashing in the FNC display.

NORMAL

The NORMAL function has ten modes numbered 0 through 9.

- The V55 uses mode 6 only and **MUST** be the active mode.

  Mode 6 - Oil Inlet and Machine Body Temperature

  - Setting Range 5.0 - 50.0EC

SETTING

The SETTING Function has ten modes numbered 0 through 9.

- The V55 does not use these modes for any reason.

MONITOR

The MONITOR function modes display current status of; temperatures, inverter frequency, and percent of direct cooling capacity.

Table 9-6 and describes each mode, their monitoring range and unit (°C, K (Kilocalorie), % or Hz).

Measurable range of the sensors is from –40° C to +180° C.

TABLE 9-6 MONITOR MODES

Mode	Description	Data Area
0	Machine body temperature	±99.9° C
1	Oil outlet temperature	
2	Air temperature	
3	Oil inlet temperature	
4	Δ T (inlet minus outlet)	
5	Present frequency of Inverter	0-90 Hz
6	Direct control of cooling capacity	0-100%
7 - 9	NOT USED	"---" Off

- In case a sensor is shorted or open; –99.9° C is displayed.

TIMER

The TIMER function has two modes; MANUAL and AUTO. The active mode flashes, below the FNC display.

- The V55 PMC controls oil controller operation. TIMER function **MUST** be set to MANUAL.

SETTING (Flashing)

When SETTING is flashing in the FNC display, the parameter setting function is active. This function has ten modes numbered 0 through 9 and **must** NOT be changed.

- The V55 uses mode 0 only.

  Mode 0 - Filter sign setting time

  - Setting Range 1 - 9 (The setting value is in hours, times 100).

MONITOR (Flashing)

When MONITOR is flashing in the FNC display, the SERVICE MONITOR function is active.

In an oil controller alarm condition, the SERVICE MONITOR function displays the alarm code in the DATA display and the alarm level in the MODE display area.

- See section 9.7 for a listing of oil controller alarms and a description of the alarm levels.

9.7 Troubleshooting and Alarms

Oil controller problems or abnormalities, are generally reflected by a PMC (machine) alarm (section 9.7.3 (pg 9-22)), but clearing a PMC alarm may not correct the alarm causing condition. So it is recommended that the Oil Controller Operation Panel LED's and Service Monitor function be checked to determine if an oil controller problem exists.

- If the troubleshooting procedures in the following sections do not correct the problem, your Makino service group.

9.7.1 Preliminary Troubleshooting

Use Table 9-7 to begin troubleshooting oil controller problems if no error indications are present.

TABLE 9-7 PRELIMINARY TROUBLESHOOTING

Condition	Cause	Remedy
Power is On, but power LED is not On.	1. Indicator board. 2. Control circuit fuse is blown.	1. Replace indicator board (PCB4). 2. Replace fuse. 3. Check for short circuit in operation circuit.
Pump runs, but no or low oil flow with air suction noise and loud pump noise.	1. Oil suction piping is loose. 2. Suction strainer is clogged. 3. Tank oil level too low. 4. Pressure loss in piping actuates relief valve and pump cavitates.	1. Tighten suction piping. 2. Clean suction strainer. 3. Change oil if dirty. 4. Correct cause of drop in oil level. Add oil or use larger diameter pipe and shorten piping.
Pump runs, but compres-sor does not.	1. Thermostat functioned properly and stops compressor. 2. Thermostat (delay timer 30 second setting) is activated. 3. Thermostat is damaged. 4. TIMER function mode is set to “AUTO”.	1. Set thermostat to low temperature side, check if compressor starts. Compressor will not start if oil temperature is too low. Wait until temp. rises. 2. Reset timer and check if compressor starts. 3. Replace thermostat. 4. Set TIMER function mode to “MANUAL”.
Compressor ran, but pump and compressor stopped. POWER and ALARM LED’s did not come On.	1. Power is Off.	1. Check main power source.
Abnormality occurred at the control circuit board.	1. Fault on control circuit board.	1. Replace control circuit board.
Pump, compressor and fan run, but oil is not cooled.	1. Obstacles near suction/ exhaust ports. 2. Air filter clogged. 3. Overloading. 4. Thermostat set too high. 5. Refrigerant gas low.	1. Remove obstacles. 2. Clean filter. 3. Eliminate the cause. 4. Set thermostat properly. 5. Recharge refrigerant.

9.7.2 Oil Controller Alarms - General

Oil controller alarm indications may appear as PMC (machine) alarms or may be internal oil controller system faults. When an oil controller related PMC alarm or abnormal oil controller operation occurs Check the Oil Controller Operation Panel for more detail.

If the panel is in NORMAL or TIMER function, the alarm code is displayed in the DATA area, the ALARM LED flashes (Level 1) or is On steady (Level 2) and the buzzer sounds.

9.7.2.1 Alarm Levels

The importance of maintaining an on-demand lubricant supply to the machine, provides two levels of oil controller alarms. Level 2 alarms (within oil controller) allow pump P1 to continue supplying lubricant to the machine. Level 1 alarms (within oil controller) stop pump operation.

The differences in alarm level are shown in results of the alarms are shown in Table 9-8.

TABLE 9-8 OIL CONTROLLER ALARM LEVELS

Level	Compressor	Pump and Fan	Alarm LED	Buzzer	Multiple Faults	Resetting Alarm
1	Stop	Stop	Flashing	On	Level 1 high level	Reset with power On or Off except E6.
2	Stop	Run	On		Level 2 low level	

Alarm Priority Processing:

Level 1 alarms are high level and level 2 alarms are low level alarms. The processing of multiple alarms depends on the alarm level and the order in which they occurred.

- A level 1 alarm occurs and then a second level 1. The second level 1 is ignored. The same happens with two level 2 alarms.
- A level 1 alarm occurs and then a level 2. The level 2 is ignored.
- A level 2 alarm occurs and then a level 1. The level 1 is indicated and processed.

9.7.2.2 Clearing Alarms

Most oil controller alarms are cleared by:

1. Pressing [POWER OFF], to power down the machine.
2. Toggling the Main Power switch from On to Off to On.
3. Pressing [CONTROL POWER ON], to power up the machine.

An exception is oil controller alarm E6 (compressor motor over current). Operating the oil controller without correcting the condition that caused the alarm may result in compressor damage (burnout, rotor lock, etc.).

- If an E6 alarm occurs, contact your Makino service group

CAUTION

E6 Alarms

E6 is a Level 2 alarm. If a Level 1 alarm occurs before the E6 is cleared, it is overwritten, canceling the E6 condition. If this happens and the machine is powered down and back up as described above, damage may occur to the oil controller and machine.

Clearing an E6 alarm:

To clear an E6 alarm, perform the following procedures:

1. Press the [FNC] key. MONITOR is displayed On steady.
2. Simultaneously press the [←] and [↑] keys.
   - MONITOR display flashes and 0 appears in MODE display and E6 in DATA display areas.
3. Press the [→] key. E6 display begins to flicker
4. Press the [ENT] key.
5. Turn the machine Off and back On.
   - The **E6** alarm is reset.

9.7.3 Oil Controller PMC Alarms

Table 9-9 lists PMC oil controller related alarms. This list is not all-inclusive, other alarms may trigger alarms causing or reflecting oil controller operation problems. Any suspected oil controller abnormality, reflected in a PMC alarm, should be investigated through the Oil Controller Operation Panel.

TABLE 9-9 OIL CONTROLLER PMC ALARMS

Oil Controller PMC Alarm	
No.	**Message**
13035	FLOW QUANTITY OF SPINDLE LUBRICANT IS ABNORMAL
13063	OILMATIC FILTER IS CLOGGED [1]
13064	OILMATIC FILTER IS CLOGGED [1]
13086	COOLANT LEVEL IS TOO LOW
13093	SPINDLE LUBRICANT FLOW SENSOR ABNORMAL
13201	SPNDL OILMATIC THERMAL IS TRIPPED [1 2]
13204	OILMATIC ALARM [1]
13205	OILMATIC FILTER IS CLOGGED [1]
13207	COMMUNICATION WITH OILMATIC IS ILLEGAL [1] (See oil controller Alarm U9)
30087	STOP AFTER M02 DUE TO OILMATIC CLOG ALARM [1]
30088	STOP AFTER M30 DUE TO OILMATIC CLOG ALARM [1]
30089	STOP AFTER M06 DUE TO OILMATIC CLOG ALARM [1]

1 “Oilmatic” is the Oil Controller Unit.
2 In the case of blown fuses or tripped breakers, determine and correct the cause before replacing the fuse or resetting the breaker.
3 Alarms 13064, 13205, and 13207 are warning versus alarm conditions.

9.7.4 Oil Controller Alarm Codes

Table 9-10 provides oil controller alarms and troubleshooting steps. Alarms are listed as they appear on the DATA display area of the operation panel.

TABLE 9-10 OIL CONTROLLER ALARM

Alarm (Level)	Condition	Possible Cause	Remedy
AA (2)	51H Thermal overload tripped.	1. Broken wire. Thermal tripped or defective. 2. PCB1 failure.	1. Check wire CN28 from PCB1. Reset thermal. Replace defective thermal. 2. Replace PCB1.
E1 (1)	PCB EEPROM abnormality.	1. PCB1 failure. Time is displayed. 2. Display PCB failure. **E-**** displayed.	1. Replace PCB1. 2. Replace PCB4.
E3 (2)	63H High-pressure switch actuated.	1. Condenser capacity reduced. Air filter or condenser clogged. 2. PCB1 Failure.	1. Clean air filter or condenser. 2. Replace PCB1.
E6	51C Compressor over-current relay activated.	1. Condenser capacity reduced. Air filter or condenser clogged. 2. Oil temperature higher than 60° C (140° F). 3. Broken wire or connector is disconnected. 4. PCB1 failure. 5. High-pressure switch damaged. 6. 49C Compressor protection thermostat damaged.	1. Clean air filter or condenser. 2. Check oil temperature using MONITOR. Wait until oil temperature goes below 50° C. Temperature increases if unit starts running at lower than 50° C. Contact your Makino service group. 3. Check wiring. Disconnect CN27 from PCB1 and reconnect. 4. Replace PCB1. 5. Turn power Off and On. **E3** is displayed. Replace high-pressure switch. 6. Turn power Off and On. **E5** displayed. Check CN26 wiring. Replace compressor protection thermostat.

TABLE 9-10 OIL CONTROLLER ALARM (CONTINUED)

Alarm (Level)	Condition	Possible Cause	Remedy
E6	51C Compressor over-current relay activated.	7. Compressor motor over-current or the compressor rotor is locked. 8. Power source voltage fluctuates ±10%.	7. Reset **E6** and check current for: 3-hp motor is less than 17A. 2-hp motor is less than 13A. Compressor runs and **E6** is displayed. Replace compressor. New compressor runs and **E6** is displayed, compressor is not at fault. 8. Verify power source is 200V ±10%.
E9 (2)	Electronic expansion valve electrical abnormality during power On operation.	1. Broken wire or connector disconnected. 2. Faulty expansion valve.	1. Check wiring. Disconnect CN14 from PCB1 and reconnect. 2. Replace expansion valve. 3.
EH (1)	51P Thermal overload is tripped.	1. Pump motor over-current or rotor locked. 2. Magnetic switch (52P-51P) abnormality. 3. Broken wire or connector disconnected.	1. Check current for pump motor is less than 3.6A. Turn power Off and On, **EH** is displayed: Over-current; replace oil pump motor. Correct current; replace magnetic switch. 2. Reset the Thermal. 3. Check wiring CN20 and CN22 from PCB1.
EJ (1)	For model AKZ306-D41B slave unit abnormality.	1. Slave unit abnormal. 2. Short circuit wiring 12-13 on Terminal Board TeS1 disconnect failure. 3. Broken wire or connector is disconnected.	1. Check slave unit AKZ206-D52 for alarms. 2. Check wiring. Check wiring. 3. Disconnect CN25 from PCB1 and reconnect.
H1 (2)	Thermistor abnormality.	1. Th1, Th3 Shorted or open. 2. Thermistor damaged.	1. Check Th1 (machine thermistor) for disconnect CN41 on PCB1. Check Th3 (air thermistor) wiring for disconnect CN43 on PCB1. 2. Thermistor with MONITOR value –99.9° C is faulty. Replace it.

TABLE 9-10 OIL CONTROLLER ALARM (CONTINUED)

Alarm (Level)	Condition	Possible Cause	Remedy
H6 (2)	CT current detection failure.	1. Broken wire or connector is disconnected. 2. Compressor improperly wired. 3. PCB failure.	1. Check wiring. Disconnect CN45 from PCB1 and reconnect. 2. Correct wiring. 3. Replace PCB2.
HH (1)	52Pa Magnetic contactor failed to activate.	1. Wiring of magnetic switch is not correct. 2. Broken wire or connector is disconnected. 3. Magnetic switch failure.	1. Check and correct wiring of magnetic switch. 2. Check wiring.Disconnect CN4 from PCB1 and CN22 from PCB2 and reconnect. 3. Replace magnetic switch.
FH (1)	High inlet oil temperature (over 60° C).	1. Cooling efficiency going down. 2. Temperature above 60° C.	1. Contact your Makino service group. 2. Wait until temperature goes below 50° C.
FE (1)	Faulty flow switch operation.	1. Broken wire or connector is disconnected. 2. Defective switch.	1. Check wiring. Disconnect CN23 from PCB1 and reconnect. 2. Replace switch.
JH (2)	Thermistor abnormality.	1. Thermistor is damaged.	1. Thermistor with MONITOR value –99.9° C faulty. Replace thermistor.
L0 (2)	Inverter system abnormality.		Contact your Makino service group.
L4 (2)	Heat radiation fin temperature rise. Heat exchanger temperature too high.	1. Dirty	1. Clean
L5 (2)	DC output overcurrent.	1. Transformer failure.	1. Check transformer “TR”.
L8 (2)	Electrical thermal.		1. Contact your Makino service group.
L9 (2)	Prevention of STOLE		1. Contact your Makino service group.
LA (2)	Power transistor abnormality.	1. Bad power module.	1. Replace power module “TM”.

TABLE 9-10 OIL CONTROLLER ALARM (CONTINUED)

Alarm (Level)	Condition	Possible Cause	Remedy
LC (2)	PCB transmission abnormality.	1. PCB failure.	1. Replace PCB1.
P1 (1)	Power source abnormality.	1. Open L1 or L3 phase on 52P magnetic contactor.	1. Check power source connections on 52P. 1. Verify power source is 200V ±10%.
P4 (2)	Inverter fin thermistor abnormal.	1. Broken wire or connector is disconnected. 2. Fin thermistor failure. 3. PCB failure.	1. Check wiring. Disconnect CN52 from PCB1 and reconnect. 2. Replace fin thermistor. 3. Replace PCB1.
U1 (1)	Power source abnormality. [1]	1. Over voltage. Over 242V. 2. Out of phase.	1. Check power source voltage. 2. Check wiring. Re-phase.
U2 (2)	Flash stop or shortage of voltage.		1. Contact your Makino service group.
U6 (1)	Transmission abnormal PCB1 to PCB4. [2]	1. Broken wire or connector is disconnected. 2. PCB1 or PCB4 failure. 3. Line noise.	1. Check wiring. Disconnect CN15 from PCB1 and cable to PCB4 and reconnect. 2. Replace PCB1 or PCB4. 3. Change wiring and/or wiring route.

[1] Power reverse phase and frequency check is conducted only once immediately after power ON. Over voltage checks are conducted continuously. Therefore, if U1 is generated during ordinary operation, the cause is always over voltage.

[2] If display communication is normal, error code U6 is displayed. If the error is in communication link with the operation panel, the operation panel cannot receive the error code. Therefore, the operation panel may be unable display the error code.

TABLE 9-10 OIL CONTROLLER ALARM (CONTINUED)

Alarm (Level)	Condition	Possible Cause	Remedy
U9 (2)	Serial or parallel transmission failure between machine and oil controller during paired operation. [3]	1. Broken wire or connector is disconnected. 2. PCB1 failure. 3. Machine transmission failure. 4. Line noise.	1. Check wiring. Disconnect CN30 and CN31 from PCB1 and reconnect. 2. Replace PCB1. 3. Check machine NC parallel transmission. 4. Change wiring and/or wiring route.
UH (1)	EEPROM abnormal.	1. Microprocessor error.	1. Replace PCB1.
UJ (2)	OP2 (slave) abnormal.	1. Broken wire or connector is disconnected.	1. Check wiring. Disconnect CN10 from PCB1 and reconnect.
[3] Code U9 is not generated when paired operation is not set.			

9.7.5 Operation Panel Alarm Codes

Table 9-11 shows the alarm codes detected by the display CPU. When the alarms are generated, E1 is generated by the temperature control.

TABLE 9-11 OPERATION PANEL ALARMS

Alarm Code	Source	Description
E-01	Power shut-off detection port error.	Power shut-off detection port remains Lo.
E-02	Key input port error.	Key input port remains Lo.
E-03	LED output error.	LED output port remains Lo.
E-04	Buzzer/LEDA output port error.	Buzzer/LEDA output port remains Lo.
E-05	RTC access error.	RTC cannot be accessed.
E-06	RTC memory data error.	RTC can be accessed, but data in memory causes check sum error.
[1] Since errors E-01 through E-05 are due to faulty hardware, resetting the equipment does not cancel these errors. When error E-06 is generated, the data is initialized and resetting the equipment cancels the error.		

9.7.6 Alarm Record in Memory

When an alarm is generated, the current data values are stored in the EEPROM error parameter memory (Table 9-12).

TABLE 9-12 ALARM MEMORY RECORD

Mode No.	Mode
0	Alarm code
1	Power supply frequency
2	Not used
3	Equipment temperature
4	Oil outlet temperature
5	Atmospheric temperature
6	Oil inlet temperature
7	Not used
8	Cumulative compressor operating hours

- The data of the first error, after power On is written into memory. If additional errors are generated, error is written based on error level processing (section 9.7.2.1).

9.8 Periodic Maintenance

Check the following items, at the recommended frequencies, to ensure proper machine performance, accuracies, and capabilities, are and maintained, throughout its life.

9.8.1 Casing

1. Polish the casing with a dry cloth. If the casing is heavily, soiled, use a high quality soap or neutral detergent.
   - Do not pour water directly on the equipment.
   - To prevent the coating from peeling, do not use brushes, polishing powder, acid, solvents, hot water, etc.

9.8.2 Tank and Filter

1. Check the oil level daily, add oil as necessary, see chapter 3.
2. Drain, clean, and refill the tank on an annual basis, see chapter 3.
3. Change the return oil filter periodically to prevent clogging, see chapter 3.
4. Change the filter immediately, if a filter clogged alarm occurs.

9.8.3 Air Filter

1. Clean the air filter at least once every two weeks. Wash with a neutral detergent when necessary.
   - Dirt and dust accumulation on air filter reduces filtering capacity, decreases air flow and may cause the condenser protective device to actuate.
   - Do not operate the oil controller without the air filter in place.
2. Clean a heavily fouled condenser with a brush or an air gun.

PM Schedule

This schedule is based on an 8 hour day, 40 hour week. Therefore one year is approximately 2,000 hours of operation.
See chapter 3 for more detail and information pertaining to PM and Lubrication of the machine tool components, recommended oils, greases, fill points, frequencies, etc.

NOTES:

SKETCHES:

Appendix A Alarms

Machine side (PMC), CNC side, Axis Servo, and Spindle Servo Module Alarms

Makino V55 High-speed Vertical Machining Center

Appendix A
Alarms

Contents

NOTES:

SKETCHES:

A.1 Overview

Listings of PMC, CNC, Axis Servo Drive Unit and Spindle Drive Unit alarms are provided in this chapter. Details on the display, reset, and meaning of each alarm type follows.

- PMC alarms are described in section A.2.
- CNC alarms are described in section A.3.
- Axis Servo Drive Unit alarms are described in section A.4.
- Spindle Drive Unit alarms are described in section A.5.

A.2 PMC (Programmable Machine Controller) Alarms

The PMC alarms presented below are listed in numerical order and grouped by software area or machine unit.

There are two types of PMC alarms.

1. Alarms, indicate component failure, misoperation, operation, improper status or conditions resulting in interrupted operation.
2. Warnings; indicate machine, operation, and programming conditions which do not halt operation but may affect or limit operation of certain functions or features.

In the alarm listing; Alarms are indicated by an exclamation point (!) and warnings are indicated by a question mark (?).

A.2.1 I/O Unit Alarms

I/O Unit Alarms

No.	Type	Message
00001	!	Group value parameter for the panel connection unit is too large
00002	!	Group value parameter for the I/O unit is doubly registered
00003	!	Group value parameter for the I/O unit is too large
00004	!	Wrong index type was set for the I/O unit
00005	!	Base value parameter for the I/O unit is too large
00006	!	Base value parameter for the I/O unit is doubly registered
00007	!	Base value parameter for the I/O unit is not continuous
00008	!	Abnormal card id for the I/O unit
00009	!	Group value parameter for the I/O unit is not continuous
00010	!	Power Mate H is assigned to two groups

A.2.2 Pallet Changer Alarms

Pallet Changer Alarms

No.	Type	Message
01000	!	Parameter specified pallet changer type is illegal
01001	?	Pallet ready is off
01002	!	Pallet ready is off
01012	!	Pallet unclamp initial condition is not arranged
01013	!	Pallet unclamp condition is lost during motion
01014	!	Pallet unclamp is not completed within the time
01027	!	Pallet clamp initial condition is not arranged
01028	!	Pallet clamp condition is lost during motion
01029	!	Pallet clamp is not completed within the time
01042	!	Pallet change is disabled as Z is not ref. point
01052	!	Pallet change is motion illegal
01053	!	Pallet is to load but a pallet stays
01054	!	Pallet is to unload but stocker is not empty
01056	!	Pallet Illegal M code is specified
01071	!	Pallet seat check is disabled as pallet is not clamped

Pallet Changer Alarms (continued)

No.	Type	Message
01072	!	Pallet seat check is disabled as no pallet on table
01073	!	Pallet seat check is disabled as low air pressure
01074	!	Pallet is not seated correctly
01095	!	Arm advance initial condition is not arranged
01096	!	Arm advance condition is lost during motion
01097	!	Arm advance is not completed within the time
01101	!	Arm retract initial condition is not arranged
01102	!	Arm retract condition is lost during motion
01103	!	Arm retract is not completed within the time
01108	!	APC S/G open initial condition is not arranged
01109	!	APC S/G open condition is lost during motion
01110	!	APC S/G open is not completed within the time
01111	!	APC S/G close. initial condition is not arranged
01112	!	APC S/G close condition is lost during motion
01113	!	APC S/G close. is not completed within the time
01124	!	Pallet down initial condition is not arranged
01125	!	Pallet down condition is lost during motion
01126	!	Pallet down is not completed within the time
01127	!	Pallet lift initial condition is not arranged
01128	!	Pallet lift condition is lost during motion
01129	!	Pallet lift is not completed within the time
01448	!	At pallet change, Y axis pos. is not fixed
01449	!	At pallet change, Y axis pos. is not stocker pos.
01450	!	APC inverter alarm
01451	!	At pallet change start, pallet on table is illegal
01452	!	At pallet load start, APC arm is not retracted
01453	!	At pallet unload start, APC arm is illegal
01454	!	Pal. uncl & lift & S/G open initial condition is not arranged
01455	!	Pal. uncl & lift & S/G open condition is lost during motion
01456	!	Pal. uncl & lift & S/G open is not completed within the time
01457	!	Pal. uncl & lift & arm adv condition is lost during motion
01458	!	Pal. uncl & down & S/G close initial condition is not arranged

Pallet Changer Alarms (continued)

No.	Type	Message
01459	!	Pal. uncl & down & S/G close condition is lost during motion
01460	!	Pal. uncl & down & S/G close is not completed within the time
01461	!	APC signal open is disabled as spindle is not stopped
01462	!	APC signal open is disabled as coolant is not stopped
01463	!	Pallet change is disabled as coolant is not stopped

A.2.3 ATC Magazine (1st axis) Alarms

ATC Magazine (1st axis) Alarms

No.	Type	Message
04003	!	A parameter specify the number of ATC mgzn pots is not set
04012	!	ATC mgzn index command is 0 or exceeds value set by parameter
04015	!	Parameter to specify ATC mgzn pot no. or pitch is illegal
04016	!	Parameter to specify ATC mgzn pot pitch is not set
04017	!	ATC mgzn axis alarm (NC-axis) is being generated
04018	!	Cannot command ATC mgzn drive because NC buffer is full
04024	!	ATC mgzn movement did not complete in the specified time
04028	!	ATC mgzn index pos. does not coincide with it commanded
04029	!	Step distance of ATC magazine is not set
04034	!	Cannot turn atc mgzn because ATC mgzn safety door is open
04035	!	ATC mgzn safety door is opened during ATC magazine turning
04168	!	Cannot turn ATC mgzn because operator-door open
04169	!	Operator-door is opened during mgzn motion
04170	?	Service is disabled because operator-door open
04171	!	Servo ready of mgzn motor axis cannot on
04172	!	Mgzn-A shifter 2 is not retracted
04173	!	Mgzn-A shifter 2 retract is shifted

A.2.4 ATC Sub-Arm Alarms

ATC Sub-Arm Alarms

No.	Type	Message
05037	!	Initial condition for pot move to standby pos. is not set
05038	!	Required position for pot move to standby pos. is lost
05039	!	Pot move to standby pos. is not end within the time
05040	!	Initial condition for pot return to mgzn-A is not set
05041	!	Required condition for pot return to mgzn-A is lost
05042	!	Pot return to mgzn-A is not end within the time
05043	!	Initial condition for pot uncl. of return to mgzn-A is not set
05044	!	Required condition for pot uncl. of return to mgzn-A is lost
05045	!	Pot uncl. of return to mgzn-A is not end within the time
05046	!	Initial condition for pot move to mgzn-B is not set
05047	!	Required condition for pot move to mgzn-B is lost
05048	!	Pot move to mgzn-B is not end within the time
05049	!	Initial condition for pot uncl. of return to mgzn-B is not set
05050	!	Required condition for pot uncl. of return to mgzn-B is lost
05051	!	Pot uncl. of return to mgzn-B is not end within the time
05052	!	Initial condition for gripper return to standby pos. is not set
05053	!	Required condition for gripper return to standby pos. is lost
05054	!	Gripper return to standby pos. is not end within the time
05055	!	Initial condition for gripper uncl. at standby pos. is not set
05056	!	Required condition for gripper uncl. at standby pos. is lost
05057	!	Gripper uncl. at standby pos. is not end within the time
05058	!	Initial condition for gripper move to mgzn-a side is not set
05059	!	Required condition for gripper move to mgzn-a side is lost
05060	!	Gripper move to mgzn-a side is not end within the time
05061	!	Initial condition for gripper uncl. at standby pos. is not set
05062	!	Required condition for gripper uncl. at standby pos. is lost
05063	!	Gripper uncl. at standby pos. is not end within the time
05064	!	initial condition for gripper move to mgzn-b side is not set
05065	!	required condition for gripper move to mgzn-b side is lost
05066	!	gripper move to mgzn-b side is not end within the time

ATC Sub-Arm Alarms (continued)

No.	Type	Message
05067	!	initial condition for pot clamp of takeout from mgzn is not set
05068	!	required condition for pot clamp of takeout from mgzn is lost
05069	!	pot clamp of takeout from mgzn is not end within the time
05070	!	initial condition for pot takeout from mgzn is not set
05071	!	required condition for pot takeout from mgzn is lost
05072	!	pot takeout from mgzn is not end within the time
05073	!	initial condition for pot move to atc-arm side is not set
05074	!	required condition for pot move to atc-arm side is lost
05075	!	pot move to atc-arm side is not end within the time
05076	!	maintenance mode is turned on during gripper motion
05077	!	gripper move is disabled due to maintenance mode on

A.2.5 ATC Alarms

ATC Alarms

No.	Type	Message
06000	!	ATC is disabled due to no reference return
06002	!	Spindle orient signal for ATC is unstable
06039	!	Initial condition for man. spndl tool clamp is not set
06040	!	Required condition for man. spndl tool clamp is lost
06041	!	Man. spndl tool clamp is not end within the time
06042	!	Initial condition for man. spndl tool uncl. is not set
06043	!	Required condition for man. spndl tool uncl. is lost
06044	!	Man. spndl tool uncl. is not end within the time
06066	?	Man. tool clamp/uncl. is disabled in auto. mode
06068	?	Man. tool clamp/uncl. is disabled due to rotating spndl
06079	!	Spndl tool uncl. is not end within the time
06081	!	Spndl tool clamp is not end within the time
06112	!	Parameter for ATC mgzn/arm type is illegal
06138	!	Spndl tool uncl. ready is not commanded
06248	!	ATC shutter open is not end within the time
06267	!	ATC shutter close is not end within the time

ATC Alarms (continued)

No.	Type	Message
06268	!	ATC shutter close is not end within the time
06340	?	Tool uncl./clamp is disabled as S/G door is not open
06388	!	Spndl is not stopped when ATC shutter is to open
06389	!	Coolant is not stopped when ATC shutter is to open
06390	!	X pos. is not fixed when ATC shutter is to close
06391	!	X pos. is out of range when ATC shutter is to close
06392	!	X or Z is not on 2nd reference point at start of ATC
06393	!	ATC mgzn index is not end within the time
06394	!	A tool stays on ATC mgzn at tool return
06395	!	No tool stays on ATC mgzn at tool return
06396	!	No tool stays on ATC mgzn at tool takeout
06397	!	A tool stays on ATC mgzn at tool takeout
06398	!	ATC mgzn index is not end normally
06399	!	Operator-side door is open
06401	!	Mgzn-side door is open
06402	!	A tool stays in spite of spndl pot no. is ‘0’
06403	!	No tool stays in spite of spndl pot no. is other than ‘0’
06404	!	Y axis pos. is not fixed at ATC start
06405	!	Spndl collides to measuring device at ATC start
06406	!	Y axis is not on reference point at ATC start
06407	!	Y axis is not on 2nd ref. point at ATC start
06408	!	ATC-arm inverter alarm
06409	!	Clamp start signal on but stop signal on is too early
06410	!	ATC arm was moved but clamp signal is not turned on
06411	!	Clamp is end but stop signal is not turned on
06412	!	Shifter or gripper (pot) pos. is illegal at ATC start
06413	!	Shifter or gripper (pot) condition is lost at arm rotate start
06414	!	Shifter or gripper (pot) condition is lost at arm rotate start
06415	!	Shifter or gripper (pot) condition is lost during arm rotate
06416	!	Shifter or gripper (pot) condition is lost during arm rotate
06417	!	Spndl uncl. condition is lost during arm rotate
06418	!	ATC arm was moved but zero signal is not turned off

ATC Alarms (continued)

No.	Type	Message
06419	!	Next tool return motion is not end
06420	!	ATC arm was moved but stop signal is not turned on

A.2.6 Spindle Alarms

Spindle Alarms

No.	Type	Message
07000	!	Condition to perform spndl CW rotation are not satisfied
07001	!	Tool clamp signal took off during spindle CW rotation
07002	!	Spindle stop sw. was pressed in starting spindle to CW
07003	!	Condition to perform spindle CCW rotation are not satisfied
07004	!	Tool clamp signal went off during spindle CCW rotation
07005	!	Spindle stop sw. was pressed in starting spindle to CCW
07019	?	Start sw was pressed without speed setting
07020	!	Spindle speed out of the allowable range is commanded
07021	!	Spndl speed command is not set when spndl CW was commanded
07022	!	Spndl speed command is not set when spndl CCW was commanded
07023	!	Condition to perform spindle orientation are not satisfied
07024	!	Spindle drive unit alarm is being generated
07025	!	Spndl stop sw. was pressed but it does not stop completely
07026	!	Spndl stop sw. was commanded but it does not stop completely
07027	!	Spndl CW was commanded but it does not stop completely
07028	!	Spndl CCW was commanded but it does not stop completely
07030	!	Spndl does not stop in changing a direction from CW to CCW
07031	!	Spndl does not stop in changing a direction from CCW to CW
07032	!	Spindle orientation does not complete
07033	!	Spindle cannot start CW because ATC-arm is not in standby
07034	!	Spindle cannot start CCW because ATC-arm is not in standby
07040	!	Cannot perform spndl orient. because ATC arm is not in standby
07043	!	Spindle parameter are not specified
07045	?	During CS-axis mode

Spindle Alarms (continued)

No.	Type	Message
07046	!	Spindle speed is not set when rigid tap was commanded
07050	!	Confirm signal don’t go on when switching spndl to high torque
07051	!	Contactor don’t turn on when switching spndl to high torque
07052	!	Fin signal does not go on when switching spndl to high torque
07053	!	Confirm signal don’t go off when switch spndl to high
07054	!	Contactor don’t turn on when switching spndl to high
07055	!	Fin signal does not go off when switch spndl to high
07056	!	Contactor to switch over spindle torque is abnormal
07120	!	Forward rotation cannot be commanded during rev. high rotation
07121	!	Reverse rotation cannot be commanded during for high rotation
07125	!	Spindle orient release cannot be completed
07140	!	Spndl cannot start as ATC shutter is open
07141	!	Tool contact is lost during rotation
07142	!	Spndl cannot start as no tool is on spndl
07143	!	Spndl cannot start as tool is not contacted to spndl
07145	!	Spndl cannot start as APC auto. door is open

A.2.7 Coolant Alarms

Coolant Alarms

No.	Type	Message
09017	?	Coolant cannot on as ATC shutter is open
09019	?	Coolant cannot on as APC auto. door is open

A.2.8 Machine Parameter and Tool Data Dump Alarms

Machine Parameter and Tool Data Dump Alarms

No.	Type	Message
11000	!	NC command is incorrect
11001	!	NC memory is full
11002	!	This program is registered already
11003	!	Command cannot be executed as program screen is open
11004	!	Writing in nc program is disabled due to memory protection
11005	!	Communication to printer is not end within the time
11006	!	Output of NC data for regist. is not started within the time

A.2.9 Thermal and Flow Switch Alarms

Thermal and Flow Switch Alarms

No.	Type	Message
13000	?	Maintenance mode is selected
13020	?	Mist collector thermal relay is tripped
13022	!	Breaker of oilmatic is tripped
13023	!	Breaker of coolant oilmatic tripped
13024	!	Breaker in cabinet is tripped
13032	?	Breaker of air dryer is tripped
13033	!	CNC alarm is being generated
13034	!	Coolant level is too low
13035	!	Flow quantity of spindle lubricant is abnormal
13036	!	Air pressure has dropped to a low level
13039	!	4^{th} axis cannot be clamped
13040	!	4^{th} axis cannot be unclamped
13041	!	5 or 6^{th} axis cannot be clamped
13042	!	5 or 6^{th} axis cannot be unclamped
13044	!	Flow quantity of nozzle coolant is abnormal
13045	!	Flow quantity of coolant through tool is abnormal
13047	!	Flow quantity of clant through spndl is abnormal
13048	!	Flow quantity of shower coolant is abnormal

Thermal and Flow Switch Alarms (continued)

No.	Type	Message
13050	?	Lift up chip conveyor did not start as manual mode
13058	!	S/G is opened
13063	!	Oilmatic filter is clogged
13064	?	Oilmatic filter is clogged
13086	!	Coolant level is too low
13093	!	Spindle lubricant flow sensor abnormal
13112	?	Primary coolant tank level is low
13129	!	Chip conveyor cannot be started due to liftup manual mode
13169	?	Rotary joint seal life signal is abnormal
13179	!	Machine lubricant cartridge replacing time
13180	!	Machine lubricant pressure is not reduced
13181	!	Machine lubricant pressure is not increased
13190	!	CNC battery voltage is low
13196	?	ATC mgzn manual intervention mode on
13197	?	APC manual intervention mode on
13201	!	Spndl oilmatic thermal is tripped
13202	!	Coolant thermal is tripped
13203	!	Protector in cabinet is tripped
13204	!	Oilmatic alarm
13205	?	Oilmatic filter is clogged
13207	?	Communication with oilmatic is illegal

A.2.10 Measuring System and Feed Axis Alarms

Measuring System and Feed Axis Alarms

No.	Type	Message
14000	!	X-axis +OT2 alarm is being generated
14001	!	X-axis -OT2 alarm is being generated
14002	!	Y-axis +OT2 alarm is being generated
14003	!	Y-axis -OT2 alarm is being generated
14004	!	Z.-axis +OT2 alarm is being generated
14005	!	Z-axis -OT2 alarm is being generated
14006	!	4th-axis +OT2 alarm is being generated
14007	!	4th-axis -OT2 alarm is being generated
14008	!	5th-axis +OT2 alarm is being generated
14009	!	5th-axis -OT2 alarm is being generated
14016	!	Automatic workpiece measuring unit alarm
14017	?	Automatic workpiece measuring head battery alarm
14018	!	Ref. point return inhibted area alarm is being generated
14019	!	Emergency Stop during auto. measuring
14028	?	Synch. mode disabled due to slave axis interlock
14030	!	Auto. operation cannot be started as spindle is not clamped
14032	?	Probe power is not turned off within the time
14033	!	Pallet is not seated
14060	!	All axes reference return is not completed
14061	!	Auto. operation cannot be started as all axes ref. isn’t completed
14066	!	Auto. operation cannot be started as spndl has no tool
14067	!	Z axis belt is broken

A.2.11 Pallet Changer Control Panel Alarms

APC Control Panel Alarms

No.	Type	Message
16005	?	APC-side S/G door is open
16071	?	Man. pallet load/unload is disabled during auto. operation
16072	?	Man. pallet load/unload is disabled during p/c motion

APC Control Panel Alarms (continued)

No.	Type	Message
16073	?	Man. pallet load/unload is disabled as pc arm is not stndby
16074	?	Man. pallet load/unload is disabled during random operation
16075	?	Man. pallet load/unload is disabled as not all axes ref.
16076	?	Pallet to be loaded is not found
16077	?	Man. pallet unload is disabled as stocker is not empty
16078	?	During man. pallet load/unload, an alarm occurs
16080	?	At man. pallet load/unload, operator-side door is open
16081	?	At man. pallet unload, no pallet on table

A.2.12 ATC Control Panel Alarms

ATC Control Panel Alarms

No.	Type	Message
18094	!	Man. intervention mode cannot be off as operator-door open
18095	?	ATC mgzn-side door is open

A.2.13 Tool Index Command (T Code) Alarms

Tool Index Alarms

No.	Type	Message
19000	!	Commanded tool is in alarm state
19001	!	Commanded tool has not been registered
19004	!	Same number is registered to more than two tools
19006	!	Commanded tool is in alarm state
19007	!	Parameter set pot no. for waiting is illegal
19008	!	Pot no. of spndl tool exceeds the max. tool number of ATC mgzn
19010	!	Pot no. of spndl tool is 0 when tool no. of dummy pot isn’t zero
19012	!	Pot no. of spndl tool coincides with pot no. of next tool
19021	!	Can’t perform T-code because ATC magazine safety door is open
19022	!	Can’t perform T-code because maintenance mode is selected
19030	!	Can’t perform T-code because operator-door is open

A.2.14 Automatic Tool Monitor Alarms

Tool Monitor Alarms

No.	Type	Message
21000	!	Z-axis command exceeds the check pos. in broken tool check
21001	!	Tool is broken
21005	!	TL monitor alarm is being generated
21011	!	Z-axis command exceeds the check pos. in broken tool check
21012	!	Tool is broken
21014	!	AC monitor alarm is being generated
21015	!	SL monitor alarm is being generated
21018	!	Work automatic measuring alarm
21019	!	Work automatic measuring alarm
21020	!	Tool at ATC pos. is broken
21021	!	Tool at ATC pos. is abnormal
21022	?	Tool at ATC pos. is broken
21023	?	Tool at ATC pos. is abnormal
21024	!	Tool checked by M434 is broken
21025	!	Tool checked by M434 is abnormal
21026	?	Tool checked by M434 is broken
21027	?	Tool checked by M434 is abnormal
21031	?	Abnormal unload key is selected
21032	!	Abnormal unload key is selected
21033	!	Data of AC function parameter is illegal

A.2.15 Cycle Start and Random Operation Alarms

Cycle Start and Random Operation Alarms

No.	Type	Message
23000	?	Random operation mode is not selected
23001	?	Random operation is being executed
23002	?	Emergency Stop is being operated
23003	?	CNC is being reset
23005	?	Splash guard door on operator side is being opened

Cycle Start and Random Operation Alarms (continued)

No.	Type	Message
23006	?	Automatic operation is being executed
23007	?	CNC alarm is being generated
23008	?	Memory or tape mode is not selected
23009	?	Reference point return is not completed
23011	!	Cannot reset CNC
23012	!	Work offset value exceed the allowable range
23013	!	Cannot register work offset value
23014	!	Cannot read work offset value
23015	!	Cannot register work offset value properly
23016	!	Cannot read the clock
23017	!	The program number is out of the specified range
23018	!	Cannot search the program
23019	!	System program is not registered in the CNC memory
23020	!	Cannot read CNC parameter
No.	**Type**	**Message**
23021	!	Feed axes is not positioned at reference point
23022	!	Cannot set optional block skip 2 to 9
23023	!	Machining program is not reg in the CNC memory
23024	!	Machining program is not reg in the CNC memory
23027	!	Cannot machine the next workpiece due to machine alarm
23032	!	CNC reset status cannot be cancelled
23046	?	Auto. operation cannot be started as spindle is not clamped
23051	!	Auto. operation cannot be started as all axes ref. is not completed
23069	!	Auto. operation cannot be started as spindle has no tool

A.2.16 Routine Functions Alarms

Routine Function Alarms

No.	Type	Message
25001	?	Cannot use routine function because feed hold is on
25002	?	Cannot use routine function during manual axis feed
25003	?	Cannot use routine function due to ref. return incomplete
25004	?	Cannot use routine function during automatic operation
25005	?	Cannot use routine function because machine lock is on
25006	?	Cannot use routine function because Z-axis neglect is on
25007	?	Tool number for specified tool change-1 is not set
25008	?	Tool number for specified tool change-2 is not set
25009	?	Tool number for specified tool change-3 is not set
25010	?	Tool number for specified tool change-4 is not set
25011	?	Tool number for specified tool change-1 is out of the range
25012	?	Tool number for specified tool change-2 is out of the range
25013	?	Tool number for specified tool change-3 is out of the range
25014	?	Tool number for specified tool change-4 is out of the range
25015	?	X-axis work set pot. data is out of the specified range
25016	?	Y-axis work set pot. data is out of the specified range
25017	?	X-axis retract pos. is not at-side in all axes ref. return
25018	?	Data for X-axis ret. pos. is illegal in all axes ref. return
25019	?	Y-axis retract pos. is not at-side in all axes ref. return
25020	?	Data for Y-axis ret. pos. is illegal in all axes ref. return
25021	?	Z-axis retract pos. is not at-side in all axes ref. return
25022	?	Data for Z-axis ret. pos. is illegal in all axes ref. return
25023	?	4-axis retract pos. is not at-side in all axes ref. return
25024	?	Data for 4-axis ret. pos. is illegal in all axes ref. return
25025	?	5-axis retract pos. is not at-side in all axes ref. return
25026	?	Data for 5-axis ret. pos. is illegal in all axes ref. return
25029	?	Command library error is being generated
25030	!	At direct spare tool chg., Z-position exceed machine zero
25031	!	Other position than specified pot is indexed
25062	?	Cannot use routine function because S/G door is not locked

A.2.17 ATC Magazine (2ND Axis) Alarms

ATC Magazine (2nd Axis) Alarms

No.	Type	Message
26000	!	Index command for atc mgzn is ‘0’ or more than parameter data
26002	!	T-code cannot performed as maintenance mode is selected
26003	!	ATC mgzn motor axis (CNC axis) alarm
26004	!	ATC mgzn command is disabled as CNC buffer is full
26005	!	ATC mgzn cannot be moved as mgzn-side door is open
26006	!	ATC mgzn-side door is opened during mgzn motion
26015	!	ATC mgzn motion end pos. differs from the command
26025	!	ATC mgzn cannot be moved as operator-side door is open
26026	!	Operator-side door is opened during mgzn motion
26028	!	Shifter3 for mgzn-B is not retracted
26029	!	Shifter3 for mgzn-B is shifted from retract pos.
26030	!	Parameter for pot no.s of ATC mgzn
26031	!	ATC mgzn-B motion is not end within the time
26032	?	Maintenance operation is disabled as operator-side door open
26033	!	Servo ready signal of ATC mgzn motor axis is not turned on
26034	!	Inching distance for ATC mgzn is not set

A.2.18 Tool Index Condition Alarms

Tool Index Condition Alarms

No.	Type	Message
27003	!	Tool’s pot no. commanded for index is illegal
27092	!	At mgzn index start, shifter1 pos. is not fixed
27093	!	At mgzn index start, shifter2 is not on retracted pos.
27094	!	At mgzn index start, shifter3 is not on retracted pos.
27095	!	At mgzn index start, gripper is not clamped
27096	!	At mgzn index start, gripper has no pot
27097	!	At mgzn index start, next tool pot no. is ‘0’
27099	!	At mgzn index start, gripper has a pot
27100	!	At mgzn index start, next tool pot no. is other than ‘0’

Tool Index Condition Alarms (continued)

No.	Type	Message
27101	!	At next tool return, indexed mgzn-B rack has a pot
27102	!	At next tool return, indexed mgzn-A rack has a pot
27103	!	At next tool return, mgzn-B rack has no pot
27104	!	At next tool return, mgzn-A rack has no pot
27105	!	At next tool takeout, indexed mgzn-B rack has no pot
27106	!	At next tool takeout, indexed mgzn-A rack has no pot
27107	!	At next tool takeout mgzn-B rack has a pot
27108	!	At next tool takeout mgzn-A rack has a pot

A.2.19 GI Function Alarms

GI Function Alarms

No.	Type	Message
29000	?	Machlock, Z-neglect, dry run disabling mode
29001	?	AC, SL, study are disabled during dry run
29002	?	Dry run is disabled during AC, SL, study

A.2.20 M, S, T Code Processing Alarms

M, S, T Code Alarms

No.	Type	Message
30002	!	Tool data has been registered for tools over mgzn pot number
30003	!	Same tool number has been registered
30004	!	Cannot read H-code
30005	!	Cannot read D-code
30006	!	Cannot register the data for H-code properly
30007	!	Cannot register the data for D-code properly
30008	!	Tool length data registered is out of the specified range
30009	!	Tool length data registered is out of the specified range
30018	!	Skip signal does not go on in ATLM circuit check
30019	!	Skip signal does not go off in ATLM circuit check
30020	!	Several tools have been registered to same PTN

M, S, T Code Alarms (continued)

No.	Type	Message
30021	!	Cannot find the PTN commanded
30022	!	Data of tool length & diameter is out of the specified range
30023	!	Cannot use the PTN commanded
30025	!	Measured length data is illegal M920 M-variable#100
30026	!	T-no. of tool length measuring is illegal m920 M-variable #109
30027	!	T-no. of tool length measuring is not registd M920 M-variable #109
30028	!	Value added t-length measured to set data is out, M922
30029	!	Tool dia. measured is out of the range M921 M-variable#100
30030	!	T-no. of tool dia. measuring is illegal M921 M-variable#109
30031	!	T-no.of tool dia. measuring is not set M921 M-variable#109
30032	!	Value added t-dia. measured to set data is out, M922
30036	!	Cannot read variable for measuring data in T-length measure
30037	!	Cannot read variable for tool number in T-length measure
30038	!	Cannot read variable for measuring data in tool dia. measure
30039	!	Cannot read variable for tool number in tool dia. measure
30042	!	Not command S-code twice at AC/SL chg mode
30043	!	Value over 30 min. rated power is input at AC/SL chg mode
30044	!	S-code was commanded more than three time at AC/SL chg mode
30045	!	gear position does not coincide with rigid tap command
30046	!	Not command S-code in tool data registration
30047	!	Value over 30 min. rated power is input at AC/SL set
30048	!	Value out of specified range was input at life set
30049	!	Value out of specified range was input at STS set
30050	!	Value other than 0 and 1 was commanded at alarm set
30051	!	M-code to set registration mode was commanded twice
30052	!	Clamp/unclamp motion is disable because 4^{th} axis is removed
30053	!	Clamp/unclamp motion is disable because 5^{th} axis is removed
30055	!	No. 1 pallet is not loaded when M84 (pal.1 load check) is given
30056	!	No. 2 pallet is not loaded when M85 (pal.2 load check) is given
30054	!	Found unusable tool at prior tool check M36

M, S, T Code Alarms (continued)

No.	Type	Message
30060	!	Pallet no. on machine table is unsettled
30061	!	Pallet no. on machine table is out of the specified range
30062	!	Cannot write pallet number into macro variable
30063	!	Cannot read macro variable properly in outputting pallet no.
30064	!	Cannot write pallet number properly
30065	!	Cannot read the clock when recording machining time
30066	!	Pallet no. on APC stocker is unsettled
30067	!	Pallet no. on APC stocker is out of the specified range
30068	!	Automatic workpiece measuring alarm is being generated
30069	!	Cannot read macro variable properly in reading pallet no.
30073	!	User M-code is not completed within the time
30074	!	Init. condition of user M-code is not arranged
30075	!	Operation no. for q’ty manage is illegal
30076	!	Number of parts for q’ty manage is over 99
30077	!	Remaining no. for q’ty manage is zero
30078	!	Operation call flag cannot be written in macro-vari
30079	!	Macro-vari cannot be read at op-call flag output
30080	!	Operation call flag cannot be written
30081	!	Macro-vari cannot be read
30087	!	Stop after M02 due to oilmatic filter clog alarm
30088	!	Stop after M30 due to oilmatic filter clog alarm
30089	!	Stop after M06 due to oilmatic filter clog alarm
30136	!	ATC is disabled as previous T motion was interrupted
30176	?	Auto. operation cannot be started as spindle is not clamped
30177	!	ITN. no. out of range is registered
30178	!	FTN. no. out of range is registered
30179	!	BTS data out of range is registered
30180	!	Tool data save is specified without S
30186	!	M/C parameter registration is disabled
30187	!	Air tool data out of range is registered
30188	!	Data out of range is specified with S
30189	!	Parameter for GI/Super-GI cannot be written correctly

M, S, T Code Alarms (continued)

No.	Type	Message
30191	!	Probe power is not turned off within the time
30192	!	Probe power is not turned on within the time
30195	!	Spndl tool life is ‘0’. TL count by M919 is disabled
30207	!	CNC parameter cannot be written correctly
30216	!	Tool draw offset cannot be cleared as ext. data input abnormal
30240	!	Cannot be written in macro variable
30241	!	At data send, macro variable cannot be read correctly
30242	!	Data cannot be written correctly
30243	!	Data designation for writing in macro is illegal
30244	!	Macro variable no. for data send is ‘0’
30245	!	At data read, macro variable cannot be read correctly
30246	!	At M483 execute, specified PTN is not found (com. var.#101)
30248	!	Stopped due to rotary joint malfunction
30268	!	Auto. operation is disabled as all axes ref. is not end
30272	!	At ATC end, mirror image cannot be resumed
30273	!	T command is not executed
30274	!	At ATC start, mirror image cannot be turned off
30275	!	Auto. operation is disabled as spndl has no tool
30276	!	Tool change is end but spndl has no tool
30277	!	At ATC start, spndl is not clamped
30285	!	At ATC start, atc arm. spndl-side has a tool
30287	!	At ATC end, spindle has a tool
30294	!	At ATC start, machine lock is on
30295	!	At ATC start, Z axis neglect is on
30297	!	M559 is not given

NOTES:

SKETCHES:

A.3 CNC Alarms

A CNC alarm is generated by the CNC (Computerized Numerical Control) and are considered Control side alarms. When a CNC alarm is generated the ALARM MESSAGE screen, with an Alarm number and brief Message, is automatically displayed. See chapter 5 for more detail on the CNC alarm display function.

A.3.1 Alarm Reset

After looking up the alarm and determining the fault, press the red [RESET] button on the CRT/MDI panel to clear the alarm.

A.3.2 CNC Alarm Format

CNC alarms range in number from 000 to 999. The alarms are divided into number groups by alarm type, as shown in Table A-1.

TABLE A-1 CNC ALARM TYPE AND NUMBER RANGE

Alarm Range	Alarm Type	Alarm Type Description
000-299	P/S	Program/Set up alarms are caused by operator error or programming/set up errors (i.e. error in program format).
300-349	APC	Absolute Pulse Coder alarms, relate to storage/transfer of absolute position data.
350-399	SPC	Serial Pulse Coder alarms are position data communication faults.
400-499	SV	SerVo alarms are generated by faults in the axis servo systems on the machine. NOTES: 1. Axis servo control is performed by the CNC. 2. Servo Drive components have self-diagnostic displays, see section A.4 (pg A-47).
500-507	OT	Over Travel alarms occur when an axis exceeds its allowable range of movement.
700-730	OH	OverHeat alarms, check the control unit and spindle unit for excessive heat.
750-799	SP	SPindle alarms are generated by errors in serial communication and should be used in conjunction with the spindle drive unit self-diagnostic display, see section A.5 (pg A-50).
900-999	SYS	SYStem alarms are generated by errors in system hardware/software.

A.3.2.1 Detail Format

In the following tables, each alarm number is followed by the on screen message and a contents column which describes the probable cause(s) of the alarm.

EXAMPLE: An example of the alarm table format is provided below.

No.	Message	Contents
000	PLEASE TURN OFF POWER	A parameter which requires the power off was input, turn off power.

- The alarms are divided into sub sections by alarm type.
- For more detail or any alarms not listed in this section refer to the CNC Maintenance Manual provided with your machine.

A.3.3 Program/Setup (P/S) Alarms

P/S Alarms

No.	Message	Contents
000	PLEASE TURN OFF POWER	A parameter which requires the power off was input, turn off power.
001	TH PARITY ALARM	TH alarm (A character with incorrect parity was input). Correct the tape.
002	TV PARITY ALARM	TV Alarm (The number of characters in a block is odd). This alarm will be generated only when the TV check is effective.
003	TOO MANY DIGITS	Data exceeding the maximum allowable number of digits was input. (Refer to the item of max. program-mable dimensions.
004	ADDRESS NOT FOUND	A numeral or the sign “-” was input without an address at the beginning of a block.
005	NO DATA AFTER ADDRESS	The address was not followed by the appropriate data but was followed by another address or EOB code.
006	ILLEGAL USE OF NEGATIVE SIGN	Sign “-” input error (Sign “-” was input after an address with which it cannot be used. Or two or more “-” signs were input.)
007	ILLEGAL USE OF DECIMAL POINT	Decimal point “.” input error (A decimal point was input after an address with which it cannot be used. Or two decimal points were input.)
009	ILLEGAL ADDRESS INPUT	Unusable character was used in significant area.
010	IMPROPER G-CODE	An unusable G code or G code corresponding to the function not provided is specified.
011	NO FEEDRATE COM-MANDED	Feedrate was not commanded to a cutting feed or the feedrate was inadequate.
015	TOO MANY AXES COMMANDED	The number of the commanded axes exceeded that of simultaneously controlled axes.
020	OVER TOLERANCE OF RADIUS	In circular interpolation (G02 or G03) difference of the distance between the start point and the center point of an arc and that between the end point and the center point of the arc exceeded the value spec-ified in parameter No. 3410.
021	ILLEGAL PLANE AXIS COMMANDED	An axis not included in the selected plane (by using G17, G18, G19) was commanded in circular interpo-lation.

P/S Alarms (continued)

No.	Message	Contents
022	NO CIRCLE RADIUS	The command for circular interpolation lacks are radius R or coordinate I, J, or K of the distance between the start point to the center of the arc.
025	CANNOT COMMAND F0 IN G02/G02	F0 (fast feed) was instructed by F1-digit column feed in circular interpolation.
027	NO AXES COM-MANDED IN G43/G44	No axis specified in G43 or G44 blocks for the tool length compensation type C. Offset is not canceled and another axis is offset for the tool length compen-sation type C.
028	ILLEGAL PLANE SELECT	In the plane selection command, two or more axes in the same direction are commanded.
029	ILLEGAL OFFSET VALUE	The offset value specified by H code is too large.
030	ILLEGAL OFFSET NUMBER	The offset number specified by D/H code for tool length offset or cutter compensation is too large.
031	ILLEGAL P COM-MAND IN G10	In setting an offset by G10, the offset number follow-ing address P was excessive or it was not specified.
032	ILLEGAL OFFSET VALUE IN G10	In setting an offset amount by G10 or in writing an offset amount by system variables, the offset amount was excessive.
033	NO SOLUTION AT CRC	A point of intersection cannot be determined for cut-ter compensation C.
034	NO CIRC ALLOWED IN ST-UP/EXT BLOCK	The start up or cancel was going to be performed in the G02 or G03 mode in cutter compensation C.
035	CAN NOT COM-MANDED G39	G39 is commanded in cutter compensation B cancel mode or on the plane other than offset plane.
036	CANNOT COMMAND G31	Skip cutting (G31) was specified in cutter compen-sation mode.
037	CANNOT CHANGE PLANE IN CRC	The plane selected by using G17, G18, or G19 is changed in cutter compensation C mode.
038	INTERFERENCE IN CIRCULAR BLOCK	Over cutting will occur in cutter compensation C because the arc start point or end point coincides with the arc center.
041	INTERFERENCE IN CRC	Over cutting will occur in cutter compensation C. Two or more blocks are consecutively specified in which functions such as the interpolation and dwell functions are performed without movement in the cutter compensation mode.

P/S Alarms (continued)

No.	Message	Contents
044	G27-G30 NOT ALLOWED IN FIXED CYC	One of G27 to G30 is commanded in canned cycle mode.
046	ILLEGAL REFERENCE RETURN COMMAND	Other than P2, P3, and P4 are commanded for 2nd, 3rd, and 4th reference point return command.
047	ILLEGAL AXIS SELECT	Two or more parallel axes (in parallel with a basic axis) have been specified upon start-up of three-dimensional tool compensation or three dimensional coordinate conversion.
048	BASIC 3 AXIS NOT FOUND	Start-up of three dimensional tool compensation or three dimensional coordinate conversion has been attempted, but the three basic used when Xp, Yp or Zp is omitted are not set in parameter 1022.
050	CHF/CNR NOT ALLOWED IN THRD BLK	Optional chamfering or corner R is commanded in the thread cutting block.
051	MISSING MOVE AFTER CHF/CNR	Improper movement or the move distance was specified in the block next to the chamfering or corner R block.
052	CODE IS NOT G01 AFTER CHF/CNR	The block next to the chamfering or corner R block is not G01, G02 or G03.
053	TOO MANY ADDRESS COMMANDS	For systems without the arbitrary angle chamfering or corner R cutting, a coma was specified. For systems with this feature, a coma was followed by something other than R or C.
055	MISSING MOVE VALUE IN CHF/CNR	In the arbitrary angle chamfering or corner R block, the move distance is less than the chamfer or corner R amount.
058	END POINT NOT FOUND	In the arbitrary angle chamfering or corner R block, the specified axis is not in the selected plane.
059	PROGRAM NUMBER NOT FOUND	The program with the selected number cannot be searched in external program number search.
060	SEQUENCE NUMBER NOT FOUND	Commanded sequence number was not found in the sequence number search.
070	NO PROGRAM SPACE IN MEMORY	The memory area is insufficient.
071	DATA NOT FOUND	The address to be searched was not found. Or the specified program number was not found in program number search.

P/S Alarms (continued)

No.	Message	Contents
072	TOO MANY PROGRAMS	The number of programs to be stored exceeded 63.
073	PROGRAM NUMBER ALREADY IN USE	The commanded program number has already been used.
074	ILLEGAL PROGRAM NUMBER	The program number is other than 1 to 9999.
075	PROTECT	An attempt was made to register a program whose number was protected.
076	ADDRESS P NOT DEFINED	Address P (program number) was not commanded in the block which includes an M98, G65, or G66 command.
077	SUB PROGRAM NESTING ERROR	The subprogram was called in five folds.
078	NUMBER NOT FOUND	A program number specified in an M98, G65, or G66 block, or a sequence number specified (by address P) in an M99 block or a GOTO statement was not found.
079	PROGRAM VERIFY ERROR	The contents of the program stored in the memory did not agree with that in tape in collation.
085	COMMUNICATION ERROR	When entering data into memory by using ASR or Reader/Puncher interface, an overrun, parity or framing error was generated. The number of bits of input data or setting of baud rate is incorrect.
086	DR SIGNAL OFF	When entering data in the memory by using Reader/Puncher interface, the ready signal (DR) of Reader/Puncher was turned off.
087	BUFFER OVERFLOW	When entering data in the memory by using Reader/Puncher interface, the read terminate command is specified, but input is not interrupted after 10 characters.
090	REFERENCE RETURN INCOMPLETE	Reference point return cannot be performed normally because the reference return start point is too close to the reference point or the speed is too slow.
091	REFERENCE RETURN INCOMPLETE	Manual reference position return cannot be performed when automatic operation is halted.
092	AXES NOT ON THE REFERENCE POINT	The commanded axis by G27 (Reference point return check) did not return to the reference point.

P/S Alarms (continued)

No.	Message	Contents
094	P TYPE NOT ALLOWED (COORD CHG)	P type cannot be specified when the program is restarted. (After automatic operation was interrupted, the coordinate system setting operation was performed.)
095	P TYPE NOT ALLOWED (EXT OFS CHG)	P type cannot be specified when the program is restarted. (After automatic operation was interrupted, the external workpiece offset changed.)
096	P TYPE NOT ALLOWED (WRK OFS CHG)	P type cannot be specified when the program is restarted. (After automatic operation was interrupted, the workpiece offset changed.)
097	P TYPE NOT ALLOWED (AUTO EXEC)	P type cannot be detected when the program is restarted. (After power ON, after Emergency Stop, or P/S94 to 97 reset. no automatic operation is performed.)
098	G28 FOUND IN SEQUENCE RETURN	A command of the program restart was specified without the reference position return operation after power ON or Emergency Stop, and G28 was found in search.
099	MDI EXEC NOT ALLOWED AFT. SEARCH	After completion of search in program restart, a move command is given with MDI.
100	PARAMETER WRITE ENABLE	Setting data PWE is set to 1. Turn it to 0 and reset the system.
101	PLEASE CLEAR MEMORY	Power was lost while edit operation was rewriting memory.
110	DATA OVERFLOW	The absolute value of fixed decimal point display data exceeds the allowable range.
111	CALCULATED DATA OVERFLOW	The calculation result of macro instruction exceeds allowable range (-2^{32} to $2^{32} - 1$).
112	DIVIDED BY ZERO	Division by zero was specified (including tan 90°).
113	IMPROPER COMMAND	The commanded function cannot be used in custom macro.
114	FORMAT ERROR IN MACRO	There is an error in other formats than <Formula>.
115	ILLEGAL VARIABLE NUMBER	A value not defined as a variable number is designated in the custom macro or in high-speed cycle machining.
116	WRITE PROTECTED VARIABLE	The left side of substitution statement is a variable whose substitution is inhibited.

P/S Alarms (continued)

No.	Message	Contents
118	PARENTHESIS NESTING ERROR	The nesting of bracket exceeds the upper limit (quintuple).
119	ILLEGAL ARGUMENT	The SQRT or BCD argument is negative, and other values than 0 to 9 are on each line of BIN argument.
122	DUPLICATE MACRO MODAL- CALL	The macro modal call is specified in double.
123	CANNOT USE MACRO COMMAND IN DNC	Macro control command is used during DNC operation.
124	MISSING END STATEMENT	DO - END does not correspond to 1:1.
125	FORMAT ERROR IN MACRO	<Formula> format is erroneous.
126	ILLEGAL LOOP NUMBER	In DOn, 1£ n £3 is not established.
127	NC, MACRO STATEMENT IN SAME BLOCK	NC and custom macro commands are confused.
128	ILLEGAL MACRO SEQUENCE NUMBER	The sequence number specified in the branch command was not O to 9999. Or, it cannot be searched.
129	ILLEGAL ARGUMENT ADDRESS	An address not allowed in <Argument Designation> is used.
130	ILLEGAL AXIS OPERATION	An axis control command was given by PMC to an axis controlled by CNC. Or an axis control command was given by CNC to an axis controlled by the PMC.
131	TOO MANY EXTERNAL ALARM MESSAGES	Five or more alarms have generated in external alarm message.
132	ALARM NUMBER NOT FOUND	No alarm No. concerned exists in external alarm message clear.
133	ILLEGAL DATA IN EXT. ALARM MSG	Small section data is erroneous in external alarm message or external operator message.
135	ILLEGAL ANGLE COMMAND	The index table indexing positioning angle was instructed n other than an integral multiple of the value of the minimum angle.
136	ILLEGAL AXIS COMMAND	In index table indexing, another axis was commanded together with the B axis.

P/S Alarms (continued)

No.	Message	Contents
137	M-CODE & MOVE CMD IN SAME BLK	A move command of other axes was specified to the same block as M code related to spindle indexing.
138	SUPERIMPOSED DATA OVERFLOW	The total distribution amount of the CNC and PMC is too large during superimposed control of the extended functions for PMC axis control.
139	CAN NOT CHANGE PMC CONTROL AXIS	An axis is selected in commanding by PMC axis control.
141	CANNOT COMMAND G51 IN CRC	G51 (Scaling ON) is commanded in the tool offset mode.
142	ILLEGAL SCALE RATE	Scaling magnification commanded is other than 1 - 999999.
143	SCALED MOTION DATA OVERFLOW	The scaling results in move distance, coordinate value and circular radius exceed the maximum command value.
144	ILLEGAL PLANE SELECTED	The coordinate rotation plane and arc or tool offset C plane must be the same.
145	ILLEGAL CONDITIONS IN POLAR COORDINATE INTERPOLATION	The condition are incorrect when the polar coordinate interpolation starts or it is cancelled. 1. In modes other than G40, G12.1/G13.1 was specified. 2. An error is found in the plane selection. Parameters 5460 and 5461 are incorrectly set.
146	IMPROPER G CODE	G code which cannot be specified in the polar coordinate interpolation mode was specified.
148	ILLEGAL SETTING DATA	Automatic corner override deceleration rate is out of the settable range of judgement angle Modify the parameters 1710 to 1714.
199	MACRO WORD UNDEFINED	Macro word undefined.
200	ILLEGAL S CODE COMMAND	In rigid tap, S value is not specified or is out of range.
201	FEEDRATE NOT FOUND IN RIGID TAP	In the rigid tap, no F value is specified.
202	POSITION LSI OVERFLOW	In the rigid tap, spindle distribution value is too large.
203	PROGRAM MISS AT RIGID TAPPING	In the rigid tap, position for a rigid M code or an S command is incorrect.
204	ILLEGAL AXIS OPERATION	In the rigid tap, an axis movement is specified between the rigid M code block and G84 (G74) block.

P/S Alarms (continued)

No.	Message	Contents
205	RIGID MODE DI SIGNAL OFF	Rigid mode DI signal is not ON when G84 (G74) is executed though the rigid M code is specified.
206	CANNOT CHANGE PLANE (RIGID TAP)	Plane changeover was instructed in the rigid mode.
210	CANNOT COMMAND M198/M099	M108 and M000 are executed in the schedule operation. M198 is executed in the DNC operation.
222	DNC OP. NOT ALLOWED IN BG.-EDIT	Input and output are executed at a time in the background edition.
224	RETURN TO REFERENCE POINT	Reference point return was not completed prior to starting automatic operations (only for Parameters 1005#0=0 ZRNx=0). Perform reference return.
231	ILLEGAL FORMAT IN G10 OR L50	Any of the following errors occurred in the specified format at the programmable-parameter input. 1) Address N or R was not entered. 2) A number not specified for a parameter was entered. 3) The axis number was too large. 4) An axis number was not specified in the axis-type parameter. 5) An axis number was specified in the parameter which is not an axis type.
232	TOO MANY HELICAL AXIS COMMANDS	Three or more axes were specified as helical axes in the helical interpolation mode.

A.3.4 Background Edit (BP/S) Alarms

BP/S Alarms

No.	Message	Contents
???	BP/S ALARM	When a BP/S alarm occurs, the same number as the P/S alarm is displayed, but it is preceded by a B. Look up the “normal” P/S alarm (070, 071, 072, 073, 074 etc.).
140	BP/S ALARM	In the background editing, Attempt to select or delete a program selected in the foreground.
239	BP/S ALARM	Background editing executed while external punching using the external I/O device control.
240	BP/S ALARM	Background editing was executed during an MDI operation.

BP/S Alarms

Alarms generated in the back ground edit are displayed in the input line (bottom of CRT) of the background edit screen, instead of the “normal” alarm message screen and is reset by the next MDI key operation.

A.3.5 Absolute Pulse Coder (APC) Alarms

APC Alarms

No.	Message	Contents
300	NTH-AXIS ORIGIN RETURN	Manual reference point return is required for the nth-axis.
301	APC ALARM: NTH-AXIS COMMUNICATION	nth-axis APC communication error. Failure in data transmission.
302	APC ALARM: NTH-AXIS OVER TIME	nth-axis APC overtime error. Failure in data transmission.
303	APC ALARM: NTH-AXIS FRAMING	nth-axis APC framing error. Failure in data transmission.
304	APC ALARM: NTH-AXIS PARITY	nth-axis APC parity error. Failure in data transmission.
† nth-axis means one of eight possible axes. Determine axis at fault.		

APC Alarms (continued)

No.	Message	Contents
305	APC ALARM: NTH-AXIS PULSE ERROR	nth-axis (n = 1-8) APC pulse error alarm. APC alarm.
306	APC ALARM: NTH-AXIS BATTERY VOLTAGE 0	nth-axis (n = 1-8) APC battery voltage has decreased to a low level so that the data cannot be held. APC alarm.
307	APC ALARM: NTH-AXIS BATTERY LOW 1	nth-axis (n = 1-8) axis APC battery voltage reaches a level where the battery must be replaced. APC alarm.
308	APC ALARM: NTH-AXIS BATTERY LOW 2	nth-axis (n = 1-8) APC battery voltage has reached a level where the battery must be replaced (including when power is OFF). APC alarm.
309	APC ALARM: n AXIS ZRN IMPOSSIBL	Return to the origin has been attempted without first rotating the motor one or more times. Before returning to the origin, rotate the motor one or more times then turn off the power.
† nth-axis means one of eight possible axes. Determine axis at fault.		

A.3.6 Serial Pulse Coder (SPC) Alarms

SPC Alarms

No.	Message	Contents
350	SPC ALARM: n AXIS PULSE CODER	The n axis (axis 1-8) pulse coder has a fault. Alarm 350 detail is displayed on CNC diagnostic No. 202 and shown in item 1. (below).
351	SPC ALARM: n AXIS COMMUNICATION	n axis (axis 1-8) serial pulse coder communication error. (data transmission fault) Alarm 351 detail is displayed on CNC diagnostic No. 203 and shown in item 2. (below).
† nth-axis means one of eight possible axes. Determine axis at fault.		

1. CNC Diagnostic display for SPC alarm 350.

NO.	#7	#6	#5	#4	#3	#2	#1	#0
202		CSA	BLA	PHA	PCA	BZA	CKA	SPHA

- CSA – Check sum alarm is being generated.
- BLA – Battery low alarm is being generated. (No relation to alarm 350)
- PHA – Phase data fault alarm is being generated.
- PCA – Speed count fault alarm is being generated.
- BZA – Battery zero alarm (battery ran out). (No relation to alarm 350)
- CKA – Clock alarm is being generated.
- SPH – Soft phase data fault alarm is being generated.

2. CNC Diagnostic display for SPC alarm 351.

NO.	#7	#6	#5	#4	#3	#2	#1	#0
203	DTE	CRC	STB					

- DTE – Data error is being generated.
- CRC – CRC error is being generated.
- STB – Stop bit error is being generated.

A.3.7 Servo (SV) Alarms

SV Alarms

No.	Message	Contents
400	SERVO ALARM: n-TH AXIS OVERLOAD	The n-th axis overload signal is on. Alarm 400 detail is displayed on CNC diagnostic No. 201 and shown in item 1. (below).
401	SERVO ALARM: n-TH AXIS VRDY OFF	The n-th axis servo amplifier READY signal (DRDY) went off.
404	SERVO ALARM: n-TH AXIS VRDY ON	Even though the n-th axis READY signal (MCON) went off the servo amplifier READY signal (DRDY) is still on. Or when the power was turned on DRDY went on even though MCON was off.
† nth-axis means one of eight possible axes. Determine axis at fault.		

SV Alarms (continued)

No.	Message	Contents
405	SERVO ALARM: (ZERO POINT RETURN FAULT)	Position control system fault. Due to a CNC or servo system fault in the reference position return, there is the possibility that reference position return could not be executed correctly. Try performing manual reference position return again.
407	SERVO ALARM: EXCESS ERROR	The difference in synchronous axis position deviation exceeded the set value.
409	SERVO ALARM: nAXIS TORQUE ALM	Abnormal servo motor load has been detected. Alternatively, abnormal spindle motor load has been detected in Cs mode.
410	SERVO ALARM: n-TH AXIS EXCESS ERROR	The position deviation value when n-th axis stops is larger than the set value.
411	SERVO ALARM: n-TH AXIS EXCESS ERROR	The position deviation value when n-th axis moves is larger than the set value.
413	SERVO ALARM: n-th AXIS LSI OVERFLOW	The contents of error register for n-th axis exceeded $\pm 2\sim^{31}$ power. This error usually occurs as the result of an improperly set parameter.
414	SERVO ALARM: n-TH AXIS DETECTION RELATED ERROR	N-th axis digital servo system fault. Alarm 414 detail is displayed on CNC diagnostic No. 200 and shown in item 3. (below).
415	SERVO ALARM: n-TH AXIS EXCESS SHIFT	Attempted setting speed higher than 511875 units/s was in the n-th axis. This error occurs as the result of improperly set CMR.
416	SERVO ALARM: n-TH AXIS DISCONNECTION	Position detection system fault in n-th axis pulse coder (disconnection alarm). Alarm 416 detail is displayed on CNC diagnostic 201 and shown in item 3. (below).
† nth-axis means one of eight possible axes. Determine axis at fault.		

SV Alarms (continued)

No.	Message	Contents
417	SERVO ALARM: n-TH AXIS PARAMETER INCORRECT	This alarm occurs when the n-th axis is in one of the conditions listed below (digital servo system alarm). 1. The value set in parameter No. 2020 (motor form) is out of the specified limit. 2. A proper value (111 or -111) is not set in parameter No.2022 (motor revolution direction). 3. Illegal data (value below 0 etc.) set in parameter No. 2023 (number of speed feedback pulses/ motor rev). 4. Illegal data (a value below 0. etc.) was set in parameter No. 2024 (number of position feedback pulses per motor revolution). 5. Parameters No. 2084 and No. 2085 (flexible field gear rate) have not been set. 6. A value outside the limit of {1 to the number of control axes} or a noncontinuous value was set in parameter No. 1023 (servo axis number).
† nth-axis means one of eight possible axes. Determine axis at fault.		

1. CNC Diagnostic display for SV alarm 400.

NO.	#7	#6	#5	#4	#3	#2	#1	#0
201	ALD							

- ALDF:

  1: Motor overheating

  0: Amplifier overheating

2. CNC Diagnostic for servo alarm 410.

NO.	#7	#6	#5	#4	#3	#2	#1	#0
200	OVL	LV	OVC	HCA	HVA	DCA	FBA	OFA

- OVL – Overload alarm exists. (Not related to alarm 414)
- LV:A – Low voltage alarm exists.
- OVC – Overcurrent alarm exists.
- HCA – Abnormal current alarm exists.
- HVA – Overvoltage alarm exists.
- DCA – Regenerative discharge circuit alarm exists.
- FBA – Disconnection alarm. (Not related to alarm No. 414)
- OFA – Overflow alarm exists.

3. CNC Diagnostic for servo alarm 416.

NO.	#7	#6	#5	#4	#3	#2	#1	#0
201	ALD			EXP				

ALD	EXP	Alarm Details
1	0	Built in pulse coder disconnection (hardware).
1	1	Separately installed pulse coder disconnection (hardware).
0	1	Pulse coder is disconnected due to software.

A.3.8 Overtravel (OT) Alarms

OT Alarms

No.	Message	Contents
500	OVER TRAVEL: + n	Exceeded n-th axis + side stored stroke limit 1.
501	OVER TRAVEL: - n	Exceeded n-th axis – side stored stroke limit 1.
502	OVER TRAVEL: + n	Exceeded n-th axis + side stored stroke limit 2.
503	OVER TRAVEL: - n	Exceeded n-th axis – side stored stroke limit 2.
506	OVER TRAVEL: + n	Exceeded n-th axis + side hardware OT.
507	OVER TRAVEL: - n	Exceeded n-th axis – side hardware OT.
510	OVER TRAVEL +n	Alarm for stroke check prior to movement. The end point specified in a block falls within the forbidden area defined with the stroke limit in the positive direction along the nth axis.
511	OVER TRAVEL -n	Alarm for stroke check prior to movement. The end point specified in a block falls within the forbidden area defined with the stroke limit in the negative direction along the nth axis.

† nth-axis means one of eight possible axes. Determine axis at fault.
‡ Parameter (No. 1326 or No. 1327) is valid when stroke limit switching signal EXLM is “1.”

A.3.9 Overheat (OH) Alarms

OH Alarms

No.	Message	Contents
700	OVERHEAT: CONTROL UNIT	Master printed circuit board overheat.
701	OVERHEAT: FAN MOTOR	The fan motor on top of the cabinet for the control unit is overheated.
704	OVERHEAT: SPINDLE	Spindle overheat in the spindle fluctuation detection.

A.3.10 Rigid Tap Alarms

Rigid Tap Alarms

No.	Message	Contents
740	RIGID TAP ALARM: EXCESS ERROR	The positional deviation of the stopped spindle has exceeded the set value during rigid tapping.
741	RIGID TAP ALARM: EXCESS ERROR	The positional deviation of the moving spindle has exceeded the set value during rigid tapping.
742	RIGID TAP ALARM: LSI OVERFLOW	An LSI overflow has occurred for the spindle during rigid tapping.

A.3.11 Spindle Alarms

Spindle Alarms

No.	Message	Contents
749	S-SPINDLE LSI ERROR	It is serial communication error while system is executing after power supply on. Following reasons can be considered: 1. Optical cable is faulty, not connected, or cut. 2. Main CPU board or Option Board 2 is faulty. 3. Spindle amplifier module is faulty. If the alarm occurs when CNC power supply is ON or alarm can not be cleared by CNC reset, turn OFF CNC power supply and power supply to spindle.

Spindle Alarms (continued)

No.	Message	Contents
750	SPINDLE SERIAL LINK START FAULT	Spindle control unit is improperly set up in a system with a serial spindle. The four main reasons are listed below: 1. An improperly connected optic cable or the spindle control unit power is OFF. 2. CNC power was turned on under alarm conditions other than SU-01 or AL-24 (which are shown on the LED display of the spindle control unit). 3. Other reasons (improper hardware combination). 4. Second spindle (when SP2 bit 4 of parameter 3701 is 1) is in one of the above conditions 1. to 3. The alarm condition in item 2. mainly occurs when CNC power dropped during start up of the serial spindle. In this case turn the spindle amplifier power OFF and perform start up again.
Details of alarm No. 750 are displayed on diagnostic No. 409, (xpage ref).		
751	FIRST SPINDLE ALARM DETECTION (AL-XX)	This alarm is generated when an alarm in the spindle unit of the serial spindle system occurs. The alarm is displayed in form AL-XX (XX is a number). Refer to the manual of the spindle control unit for alarm contents. The signal for the number of the alarm which is detected by the CNC is latched and the alarm number is displayed.
752	FIRST SPINDLE MODE CHANGE FAULT	This alarm occurs if the system does not properly terminate a mode change. The modes include the contouring spindle positioning, rigid tapping, and spindle control modes. The alarm is activated if the spindle control unit does not respond correctly to the mode change command issued by the CNC.
754	SPINDLE-1 ABNORMAL TORQUE FAULT	Abnormal first spindle motor load has been detected.
761	SECOND SPINDLE ALARM DETECTION (AL-XX)	Refer to alarm No. 751.
762	SECOND SPINDLE MODE CHANGE FAULT	Refer to alarm No. 752.

1. CNC Diagnostics for spindle alarm 750.

NO.	#7	#6	#5	#4	#3	#2	#1	#0
409					SPE	S2E	S1E	SHE

- SPE:

  0: Serial spindle control parameters match the spindle unit start up conditions.

  1: Serial spindle control parameters do not match the spindle unit start up conditions.

- S1E:

  0: The 1st spindle serial start up was normal.

  1: The 1st spindle was detected to have a fault during serial start up.

- SHE:

  0: The serial communication module in the CNC is normal.

  1: A fault was detected in the serial communication module.

A.3.12 System Alarms

SYS Alarms

No.	Message	Contents
900	ROM PARITY	ROM parity error (CNC/OMM/Servo).
910	RAM PARITY: (4N)	RAM parity error in the tape memory RAM module. Clear the memory or replace the module.
911	RAM PARITY: (4N + 1)	RAM parity error in the tape memory RAM module. Clear the memory or replace the module.
912	RAM PARITY: (4N + 2)	RAM parity error in the tape memory RAM module. Clear the memory or replace the module.
913	RAM PARITY: (4N + 3)	RAM parity error in the tape memory RAM module. Clear the memory or replace the module.
914	SRAM PARITY (2N)	A RAM parity error occurred in RAM for part program storage or additional SRAM. Clear the memory, or replace the Main CPU board or additional SRAM. Then set all data, including parameters.
915	SRAM PARITY (2+1)	
916	DRAM PARITY	RAM parity error in DRAM module. Replace the DRAM module.

SYS Alarms (continued)

No.	Message	Contents
920	SERVO ALARM (MAIN)	Servo alarm (Main CPU board). A watchdog alarm or a RAM parity error in the servo module occurred. Replace the servo control module on the Main CPU board.
921	SERVO ALARM (3/4 AXIS)	Servo alarm (3rd or 4th axis). A watchdog alarm or a RAM parity error in the servo module occurred.
922	SERVO ALARM (OPT2)	Servo alarm (Option 2 board). A watchdog alarm or a RAM parity error in the servo module occurred. Replace the servo control module on the Option 2 board.
923	SERVO ALARM (7/8 AXIS)	Servo alarm (7th or 8th axis). A watchdog alarm or a RAM parity error in the servo module occurred.
924	SERVO MODULE SETTING ERROR	The digital servo module is not installed.
930	CPU INTERRUPT	CPU error (abnormal interrupt).
940	PCB ERROR	ID error of PCB. Main module or main board is faulty.
945	SERIAL SPINDLE COMMUNICATION ERROR	Communications error occurred in the serial spindle. The optical fiber may be disconnected.
950	PMC SYSTEM ALARM	Fault occurred in the PMC.
951	PMC-RC WATCH DOG ALARM	Fault occurred in the PMC-RC (watchdog alarm).
970	NMI OCCURRED IN BOC	RAM parity error or NMI occurred in the PMC-RB or PMC-RA2 module.
971	NMI OCCURRED IN SLC	SLC communications error occurred in the PMC-RB, PMC-RA1, or PMC -RA2.
972	NMI OCCURRED IN OTHER MODULE	NMI occurred on a board other than main CPU board.
973	NON MASK INTER-RUPT	NMI occurred for an unknown reason.
974	F-BUS ERROR	Error in Fanuc BUS. Main CPU and OPTION 1 to 3 boards may be faulty.
975	BUS ERROR (MAIN)	Main CPU board BUS error. Main CPU board may be faulty.

A.3.13 PMC Alarms

PMC Alarms

No.	Message	Contents
	ALARM NOTHING	Normal state.
ER 00	PROGRAM DATA ERROR (ROM)	Sequence program in the user ROM is incorrect or defective.
ER 01	PROGRAM DATA ERROR (RAM)	Sequence program in the user RAM is incorrect or defective.
ER 02	PROGRAM SIZE OVER	The size of a ladder program is out of range (only for PMC-RC).
ER 03	PROGRAM SIZE ERROR (OPTION)	The size of a ladder program exceeds the optionally specified size.
ER 04	LADDER OBJECT TYPE ERROR	The PMC model setting of the sequence program is not corresponding to an actual model.
ER 05	PMC MODULE TYPE ERROR	The module type of the PMC engine is wrong (only for PMC-RC).
ER 06	PROGRAM MODULE NOTHING	No ROM or RAM for user programs (only for PMC-RC).
ER 07	NO OPTION (LADDER STEP)	No option for the number of ladder steps.
ER 16	RAM CHECK ERROR (PROGRAM RAM)	An error occurred in the RAM for user programs.
ER 17	PROGRAM PARITY	A parity error occurred in the ROM or RAM for user programs.
ER 18	PROGRAM DATA ERROR BY I/O	Either a power failure occurred during sequence transfer or sequence transfer from the off-line programmer was interrupted.
ER 19	LADDER DATA ERROR	Either a power failure occurred in ladder program editing or editing a ladder program was interrupted.
ER 20	SYMBOL/COMMENT DATA ERROR	Either a power failure occurred in symbol and comment editing or editing symbols or comments was interrupted.
ER 21	MESSAGE DATA ERROR	Either a power failure occurred in message editing or editing messages interrupted.
ER 22	PROGRAM NOTHING	No ladder program.
ER23	PLEASE TURN OFF POWER	The maximum capacity of a ladder program has changed. Turn off the power.

† If any alarm, ER00 - ER23, is issued, a sequence program does not start.

‡ Alarm messages WN17 to WN33 indicate errors related to PMC-RC user C programs.

PMC Alarms (continued)

No.	Message	Contents
ER32	NO I/O DEVICE	No external I/O unit is connected.
ER33	SLC ERROR	The LSI chip for I/O Link is defective.
ER34	SLC ERROR (xx)	The LSI chip in the I/O unit of group xx is defective or a transmission error has occurred.
ER35	TOO MUCH OUTPUT DATA IN GROUP (XX)	The length of output data in group xx exceeds 32 bytes. Excessive data is ignored.
ER36	TOO MUCH INPUT DATA IN GROUP (XX)	The length of input data in group xx exceeds 32 bytes. Excessive data is ignored.
ER37	TOO MUCH SLOT IN BASE	The number of slots exceeds 10. The eleventh and subsequent slots are invalid.
ER38	MAX SETTING OUTPUT DATA OVER (xx)	The capacity of the I/O area is insufficient. Assigning output group xx or groups having larger numbers is invalid.
ER39	MAX SETTING INPUT DATA OVER (xx)	The capacity of the I/O area is insufficient. Assigning input group xx or groups having larger numbers is invalid.
WN01	LADDER MAX SIZE ERROR	The MAX LADDER AREA SIZE in the system parameter is illegal.
WN02	OPERATOR PANEL ADDRESS ERROR	The address setting data of the operator's panel for FS-0 is illegal.
WN03	ABORT NC-WINDOW/EXIN	LADDER was stopped while CNC and PMC were communicating.
WN04	UNAVAIL EDIT MODULE	The LADDER editing module cannot be recognized/
WN06	TASK STOPPED BY DEBUG FUNC	Some user tasks are stopped by break point of the debugging function.
WN07	LADDER SP ERROR (STACK)	When functional instruction CALL(SUB65) or CALL(SUB66) was executed, the stack of the ladder overflowed.
WN17	NO OPTION (LANGUAGE)	The LANGUAGE option was not found.
WN18	ORIGIN ADDRESS ERROR	The LANGUAGE ORIGIN address is out of range.

† If any alarm, ER00 - ER23, is issued, a sequence program does not start.

‡ Alarm messages WN17 to WN33 indicate errors related to PMC-RC user C programs.

PMC Alarms (continued)

No.	Message	Contents
WN 19	GDT ERROR (BASE, LIMIT)	User-defined GDT error (BASE, LIMIT, or entry over).
WN 20	COMMON MEM. COUNT OVER	The number of shared memory units is nine or more.
WN 21	COMMON MEM. ENTRY OVER	The GDT entry of shared memory is out of range.
WN 22	LADDER 3 PRIORITY ERROR	LADDER LEVEL 3 priority error.
WN 23	TASK COUNT OVER	Too many user tasks.
WN 24	TASK ENTRY ADDER ERROR	The selector of the user task entry address is out of range.
WN 25	DATA SEG ENTRY ERROR	The DATA segment entry is out of range.
WN 26	USER TASK PRIOR-ITY ERROR	The user TASK priority is out of range.
WN 27	CODE SEG TYPE ERROR	Invalid code segment type.
WN 28	DATA SEG TYPE ERROR	Invalid data segment type.
WN 29	COMMON MEM SEG TYPE ERROR	Invalid shared memory segment type.
WN 30	IMPOSSIBLE ALLO-CATE MEM.	The memory area can not be allocated to the work area or stack area.
WN 31	IMPOSSIBLE EXE-CUTE LIBRARY	A library function can not be executed.
WN 32	LNK CONTROL DATA ERROR	Invalid data in a link control statement (program con-trol).
WN 33	LNK CNTL DATA VER. ERROR	Invalid edition in a link control statement (program control).
PC1 nn	CPU INTERRUPT	A CPU error (abnormal interrupt) occurred - refer to CNC Maintenance Manual for details.
PC1 30	RAM PARITY	A parity error occurred on the debugging RAM of PMC - refer to CNC Maintenance Manual for details.

† If any alarm, ER00 - ER23, is issued, a sequence program does not start.

‡ Alarm messages WN17 to WN33 indicate errors related to PMC-RC user C programs.

PMC Alarms (continued)

No.	Message	Contents
PC1 40	NMI BOC bb xxxx yyyyy	The RAM parity error or NMI (Non Maskable Interrupt) generated in module of PMC engine - refer to CNC Maintenance Manual for details.
PC1 50	NMI SLC aa cc	A communication error occurred in the I/O link - refer to CNC Maintenance Manual for details.
PC1 60	F-BUS ERROR xxxx yyyyy	A BUS error (access to disabled address) occurred - refer to CNC Maintenance Manual for details.
PC1 99	ROM PARITY eeeeeeee	A parity error occurred in PMC system ROM - refer to CNC Maintenance Manual for details.

† If any alarm, ER00 - ER23, is issued, a sequence program does not start.

‡ Alarm messages WN17 to WN33 indicate errors related to PMC-RC user C programs.

A.4 Axis Servo Drive Alarms

Axis Drive status is indicated by a 7-segment STATUS display. The PSM (Power Supply Module) has two 7-segment displays and each SVM (Servo Amplifier Module) has one. As conditions change within a module the status display indicates the related number or letter indicating current status. For more detail on the servo unit self-diagnostics see chapter 5 of the Maintenance Guide.

- section A.4.1 lists the PSM alarms
- section A.4.2 lists SVM alarms

A.4.1 Power Supply Module Alarms

Table A-2 lists the Axis Servo Drive - PSM status display; symbols, meaning, and description.

TABLE A-2 AXIS PSM SELF-DIAGNOSTIC ALARM

Status	Type	Description
-.-	*NOT READY	The power supply module is not ready to drive a motor.
0.0	*READY	The power supply module has charged its DC voltage section and is ready to drive a motor.
0.1	INPUT OVERCURRENT	An overcurrent flowed in the input circuit.
0.2	FAN ALARM	Built-in power supply module fan failure.
0.3	OVERLOAD	Semiconductor heat sink is too hot.
0.4	DC LINK LOW VOLTAGE	The DC voltage in the main circuit is too low.
0.5	DC LINK INSUFFICIENT CHARGE	The DC voltage in the main circuit has not reached a sufficiently high level (insufficient precharge)
0.6	INPUT POWER MISSING PHASE	The input power is missing a phase.
0.7	DC LINK OVERVOLTAGE	The DC power voltage in the main circuit is too high.
0.8	HARDWARE ERROR	The control circuit has failed.

* These items indicate normal operating status and are not alarm conditions.

A.4.2 Servo Amplifier Module Alarms

Table A-3 lists the Servo Drive - Amplifier Module status display; symbols, meaning, and description.

TABLE A-3 AXIS SVM SELF-DIAGNOSTIC ALARMS

Status	Type	Description
–	*NOT READY	Amplifier module is not ready to drive a motor.
0	*READY	Amplifier module is ready to drive a motor.
1	FAN ALARM (FAL)	Built-in amplifier module fan failure.
2	CONTROL POWER LOW VOLTAGE (LV5V)	The control power voltage (+5 V) is too low or the clock is erroneous.
5	DC LINK LOW VOLTAGE (LVDC)	The DC voltage in the main circuit is too low.
8	OVERCURRENT (HCL)	An overcurrent flowed in the X axis motor.
9	OVERCURRENT (HCM)	An overcurrent flowed in the Y axis motor.
A	OVERCURRENT (HCN)	An overcurrent flowed in the Z axis motor.
b	OVERCURRENT (HCLM)	An overcurrent flowed in the X and Y axes motors.
C	OVERCURRENT (HCMN)	An overcurrent flowed in the Y and Z axes motors.
d	OVERCURRENT (HCLN)	An overcurrent flowed in the X and Z axes motors.
E	OVERCURRENT (HCLMN)	An overcurrent flowed in the X, Y, and Z axes motors.
8.	IPM ALARM (HCL)	Error detected in the IPM in the X axis amplifier. †
9.	IPM ALARM (HCM)	Error detected in the IPM in the Y axis amplifier. †

* These items indicate normal operating status and are not alarm conditions.

† When a servo alarm occurs, dynamic braking is applied to stop motor rotation. IPM (Input Power Module) alarms are indicated by a decimal (.) point displayed in the lower right corner of the display. IPM alarms result when overcurrent or overheating condition is detected in an element or low control power voltage.

TABLE A-3 AXIS SVM SELF-DIAGNOSTIC ALARMS (CONTINUED)

A.	IPM ALARM (HCN)	Error detected in the IPM in the Z axis amplifier. †
b.	IPM ALARM (HCLM)	Error detected in the IPM on X and Y axes amplifiers. †
C.	IPM ALARM (HCMN)	Error detected in the IPM's in the Y and Z axes amplifiers. †
d.	IPM ALARM (HCLN)	Error detected in the IPM's in the X and Z axes amplifiers. †
E.	IPM ALARM (HCLMN)	Error detected in the IPM's in the X, Y, and Z axes amplifiers. †

* These items indicate normal operating status and are not alarm conditions.

† When a servo alarm occurs, dynamic braking is applied to stop motor rotation. IPM (Input Power Module) alarms are indicated by a decimal (.) point displayed in the lower right corner of the display. IPM alarms result when overcurrent or overheating condition is detected in an element or low control power voltage.

A.5 Spindle Drive Alarms

Spindle drive unit status is indicated by A 7-segment STATUS display. Both the PSM (Power Supply Module) and the SPM (Spindle Amplifire Module) have two 7-segment displays. As module conditions/operations change the status display indicates a related number or letter, indicating current status. For more detail on the servo unit self-diagnostics see chapter 5 of the Maintenance Guide.

- On the PSM – When the ALM LED is On, see section A.5.1.
- On the SPM – When the ALM or ERR LED is On, see section A.5.2.

A.5.1 Power Supply Module Alarms

When the ALM LED on the PSM is On, see Table A-4 for a description of the alarm condition.

TABLE A-4 SPINDLE PSM SELF-DIAGNOSTIC ALARMS

Status	Type	Description
-.-	*NOT READY	Power supply module is not ready to drive a motor.
0.0	*READY	Power supply module has charged its DC voltage section and is ready to drive a motor.
0.1	INPUT OVERCURRENT	An overcurrent flowed in the input circuit.
0.2	FAN ALARM	Built-in power supply module fan failure.
0.3	OVERLOAD	Semiconductor heat sink is too hot.
0.4	DC LINK LOW VOLTAGE	DC voltage in the main circuit is too low.
0.5	DC LINK INSUFFICIENT CHARGE	DC voltage in the main circuit has not reached a sufficiently high level (insufficient pre-charge)
0.6	INPUT POWER MISSING PHASE	Input power is missing a phase.
0.7	DC LINK OVERVOLTAGE	DC power voltage in the main circuit is too high.
0.8	HARDWARE ERROR	The control circuit has failed.

* These items indicate normal operating status and are not alarm conditions.

A.5.2 Spindle Amplifier Module Status Displays

The spindle amplifier module 7-segment displays are used to indicate both alarm and error conditions.

- If the amplifier module ALM LED is On, see section A.5.2.1
- If the amplifier module ERR LED is On, see section A.5.2.2

A.5.2.1 Spindle Amplifier Module Alarms

When the SPM ALM LED is On, see Table A-5 for a description of the alarm condition.

TABLE A-5 SPINDLE SPM SELF-DIAGNOSTIC ALARMS

Status	Type	Description
-.- (Blinking)	*WAITING FOR SERIAL DATA TRANSFER	Parameter loading from the CNC has not completed.
-.- (Steady)	*NOT READY	Motor is not excited. The amplifier module inverter output is turned OFF.
0.0	*READY	Motor is excited. The amplifier module inverter output is turned ON.
A.0	PROGRAM ROM ERROR	Control program is not operating (ROM uninstalled).
A.1	PROGRAM RAM ERROR	Control program is not running (RAM error).
0.1	MOTOR OVERHEAT	Motor temperature has exceeded its set limit.
0.2	EXCESSIVE VELOCITY ERROR	Excessive deviation between commanded and actual motor speed.
0.3	BLOWN FUSE FOR DC LINK	Blown fuse in the DC Link.
0.4	INPUT POWER MISSING PHASE	The input power is missing a phase.
0.7	OVERSPEED	The motor has exceeded 115% of its rated speed.
0.9	OVERLOAD	The semiconductor heat sink is too hot.
1.1	OVERVOLTAGE IN DC LINK	DC voltage in the main circuit is too high.

TABLE A-5 SPINDLE SPM SELF-DIAGNOSTIC ALARMS (CONTINUED)

12	OVERCURRENT THROUGH DC LINK	An overcurrent flowed in the DC Link of the input circuit.
13	CPU MEMORY ERROR	The CPU internal data memory is erroneous. The CPU internal data memory is checked only when power is first turned ON.
15	SPINDLE RANGE SWITCHING/SPINDLE SWITCHING	The spindle speed range or spindle switching sequence is incorrect.
16	RAM ERROR	External RAM data is erroneous. External RAM data is checked only when power is first turned ON.
19	EXCESSIVE OFFSET FOR U-PHASE CURRENT DETECTOR	The offset for the U-Phase current detector is too large. The offset is checked only when power is first turned ON.
20	EXCESSIVE OFFSET FOR V-PHASE CURRENT DETECTOR	The offset for the V-Phase current detector is too large. The offset is checked only when power is first turned ON.
24	SERIAL DATA TRANSFER ERROR	Serial transfer data is erroneous (e.g., when NC power is OFF).
25	SERIAL DATA TRANSFER STOPPED	Transfer of serial data has stopped.
26	SPEED DETECTION SIGNAL	A disconnection alarm for Cs contouring control if the speed detection signal is erroneous (e.g. due to improper adjustment).
27	POSITION CODER SIGNAL	A disconnection alarm if the position coder signal is erroneous (e.g. due to improper adjustment or incorrect setting).
28	POSITION DETECTION SIGNAL	A disconnection alarm for Cs contouring control if the position detection signal is erroneous (e.g. due to improper adjustment).
29	SHORT PERIOD OVERLOAD	An overload was applied during a certain period (while the spindle was clamped for positioning).
30	OVERCURRENT INPUT	An overcurrent flowed in the input circuit of the power supply module.
31	SPEED DETECTION SIGNAL	A disconnection alarm. The motor cannot rotate at the commanded speed due to excessively low speed or a clamped motor alarm.
32	SERIAL DATA TRANSFER	An LSI internal RAM error for serial data transfer. LSI internal RAM is checked only when the power is first turned ON.

TABLE A-5 SPINDLE SPM SELF-DIAGNOSTIC ALARMS (CONTINUED)

3.3	DC LINK CHARGING	A error generated when charging of the main circuit is not completed within the specified time.
3.4	PARAMETER DATA OUT OF RANGE	Parameter data was set outside the supported range.
3.5	GEAR RATIO DATA	Gear ratio data was set outside the supported range.
3.6	EXCESSIVE POSITION	The error counter has overflowed.
3.7	SPEED DETECTION PARAMETER	An invalid speed detection parameter setting alarm causing the motor not to decelerate upon Emergency Stop.
3.9	ONE-ROTATION SIGNAL	An invalid Cs contouring control one-rotation signal was detected.
4.0	ONE-ROTATION SIGNAL	A Cs contour control one-rotation signal was not detected.
4.1	ONE-ROTATION SIGNAL	A Cs contour control one-rotation signal for the position coder was not detected normally.
4.2	ONE-ROTATION SIGNAL	A Cs contour control one-rotation signal for the position coder was not generated.
4.3	POSITION CODER	Disconnection alarm, main spindle position coder signal, differential speed mode, is not connected.
4.4	A/D CONVERSION	The A/D converter has failed.
4.6	ONE-ROTATION SIGNAL	Generation of the position coder one-revolution signal has stopped during a threading operation.
4.7	POSITION CODER	The position coder signal has not been correctly counted.
4.9	DIFFERENTIAL SPEED	The speed, converted from the speed of another spindle, exceeds the maximum in the differential speed mode.
5.0	SYNCHRONIZATION CONTROL	The calculated value for the specified speed exceeds the maximum in spindle synchronization control.
5.1	LOW VOLTAGE - DC LINK	The DC voltage in the main circuit of the power supply module is too low.
5.2	ITP SIGNAL ALARM I	The signal for synchronization with the CNC (ITP signal) is erroneous (detected when the ITP signal is turned off.
5.3	ITP SIGNAL ALARM II	The signal for synchronization with the CNC (ITP signal) is erroneous (detected when the ITP signal is turned off.

TABLE A-5 SPINDLE SPM SELF-DIAGNOSTIC ALARMS (CONTINUED)

5.4	OVERCURRENT	An overcurrent flowed in the motor for an extended period.
5.5	SPINDLE or SPEED RANGE SWITCHING	The switching request and power line condition check signals to not match.
5.6	FAN ALARM	The spindle amplifier module fan has failed.
5.7	HARDWARE ERROR	The control circuit is erroneous.
5.8	OVERLOAD	The power supply module semiconductor heat sink is too hot.
5.9	FAN ALARM	The power supply module fan has failed.

A.5.2.2 Spindle Amplifier Module Errors

When the SPM ERR LED is On, see Table A-6 for a description of the error condition. These error conditions typically occur as the result of incorrect parameter settings or improper operating sequence.

TABLE A-6 SPINDLE SPM SELF-DIAGNOSTIC ERRORS

Status	Type	Description
0.1	PARAMETER SETTING	Although *ESP and MRDY signals are not input, SFR/SRV/ORCM is input. (Three types of *ESP signals are: E-Stop, connection, and DI). Regarding MRDY (machine ready) siganl pay attention to use/not use setting of parameter MRDY.
0.2	PARAMETER SETTING	Attempt to excite motor failed due to incorrect parameter setting. When the motor is not integral with the spindle and a high resolution magnetic pulse coder is used, the speed detector of spindle motor is set to 128 8 /rev.
0.3	OPERATING SEQUENCE	Parameter without high-resolution magnetic pulse coder is set, but Cs contouring control command is entered. The motor is not excited.
0.4	OPERATING SEQUENCE	Although parameter setting for using position coder signal was not set, commands for servo mode and synchronous control are input. The motor is not excited.
0.5	OPERATING SEQUENCE	Although the option parameter for orientation is not set, the orientation function command (ORCM) is input.

TABLE A-6 SPINDLE SPM SELF-DIAGNOSTIC ERRORS (CONTINUED)

0.6	OPERATING SEQUENCE	Although option parameter for output switch-over control function is not set, LOW winding is selected.
0.7	OPERATING SEQUENCE	Although the Cs contouring command was entered, SFR/SRV is not entered.
0.8	OPERATING SEQUENCE	Although the servo mode control command was input, SFR/SRV is not input.
0.9	OPERATING SEQUENCE	Although synchronous control command was input, SFR.SRV is not input.
1.0	OPERATING SEQUENCE	Cs control command entered, but another mode (servo mode, synchronous control, orientation) is specified.
1.1	OPERATING SEQUENCE	Servo mode command entered, but another mode (Cs contouring control, synchronous control, orientation) is specified.
1.2	OPERATING SEQUENCE	Synchronous control command entered, but another mode (Cs contouring control, servo mode, synchronous control) is specified.
1.3	OPERATING SEQUENCE	Orientation command entered, but another mode (Cs contouring control, servo mode, synchronous control) is specified.
1.4	OPERATING SEQUENCE	SFR/SRV are simultaneously commanded.
1.5	PARAMETER SETTING	Cs contouring control command entered when differential speed control function enabled by parameter. (CNC Param: 4000 Bit 5 = 1).
1.6	PARAMETER SETTING	Differential mode command (DEFMD) entered when differential speed control function disabled by parameter. (CNC Param: 4000 Bit 5 = 0).
1.7	PARAMETER SETTING	Parameter setting (CNC Param: 4011 Bits 0, 1, and 2) for speed detector is incorrect. (Specified speed detector is not present.)
1.8	PARAMETER SETTING	Spindle orientation command (position coder type) entered when position coder is disabled by parameter. (CNC Param: 4001 Bit 2 = 0)
1.9	OPERATING SEQUENCE	Although the command for orienting the magnetic sensor system was entered, another mode was issued.
2.0	OPERATING SEQUENCE	Both the slave mode and the high resolution magnetic pulse coder were enabled.

TABLE A-6 SPINDLE SPM SELF-DIAGNOSTIC ERRORS (CONTINUED)

2.1	OPERATING SEQUENCE	Slave mode command (SLV=1) was entered under position control (servo mode, orientation, etc.)
2.2	OPERATING SEQUENCE	The position control command (servo mode, orientation, etc.) was entered in the slave operation mode (SLV=1).
2.3	PARAMETER SETTING	A slave mode command (SLV=1) was entered when the slave mode is disabled.
2.4	PARAMETER SETTING	To perform continuous indexing mode for orienting position coder system, incremental operation (INCMD = 1) was first performed, then absolute position command (9INCMD = 0) was entered.

NOTES:

SKETCHES:

NOTES:

SKETCHES:

Appendix B Machine Diagnostics

I/O Communication Signals from PMC
to MT and Operator Panel

Makino V55 High-speed Vertical
Machining Center

MAKINO

Appendix B
Machine Diagnostics

Contents

B.1 Overview

Machine diagnostics consist of the DI/DO (Data Input/ Data Output) signals used for communication between the PMC and the MT (Machine Tool) and the PMC and the OP (Operator’s Panel).

Machine diagnostic signals are powerful tools and should be viewed during troubleshooting (PMC or Machine side alarms) and repair (component adjustment or replacement).

- These signals are specific to the Makino V55 Vertical with Makino PRO 3 Control.

Machine Diagnostics

1. The PMC is also referred to as the CUSTOM side because it contains Makino’s customized software.
2. DI/DO stands for Data Input/Data Output and allows the signal’s direction or flow to be established.

B.2 Format

Machine diagnostic data is presented with a table for each diagnostic address, as shown in Figure B-1, with minor differences between inputs and outputs. Table format details are provided below.

Diagnostic: 000		**PMC Address** **X00**	**I/O Unit** Group 0/Base 0/Slot 1		
Bit	**Signal Name**	**Meaning**	**IN**	**COM**	**Page**
7	RCH2	Spindle Rotor Condition Confirm 2	A20	C24L (CMA) A24 B24	13/6D
6	RCH1	Spindle Rotor Condition Confirm 1	B20		13/6D
5	-	-	A21		-
4	LS1340	Union Abnormal Detection	B21		201/6D
3	LS602	Tool Not Detection	A22		201/5D
2	LS601	Tool Fitting Confirm	B22		201/4D
1	LS01	Tool Unclamp	A23		201/3D
0	LS00	Tool Clamp	B23		201/2D

FIGURE B-1 MACHINE DIAGNOSTICS DI/DO TABLE EXAMPLE

B.2.1 Table Heading

Figure B-2 shows the Diagnostic I/O table heading information.

Diagnostic: The Diagnostic address number viewed on the CUSTOM diagnostic screen.

PMC Address: The signal's PMC address as shown in the Schematics and Mechanical chapters.

Diagnostic: 000	PMC Address X00	I/O Unit Group 0/Base 0/Slot 1

I/O Unit: The signal location within the I/O rack.

FIGURE B-2 I/O TABLE HEADING DETAIL

B.2.2 Table Body

The I/O table body (Figure B-3) includes the following data:

BIT: Bit numbers represent the signal data bit location within the Diagnostic address. Each address consists of eight data bits, numbered 0 thru 7 and read from right to left.

SIGNAL NAME: The signal name as used in the Schematics. Signals preceded by (*) are normally high!

MEANING: Description of the signal's function or meaning.

Bit	Signal Name	Meaning	IN	COM	Page
7	RCH2	Spindle Rotor Condition Confirm 2			
6	RCH1	Spindle Rotor Condition Confirm 1			
5	-	-			
4	LS1340	Union Abnormal Detection			
3	LS602	Tool Not Detection			
2	LS601	Tool Fitting Confirm			
1	LS01	Tool Unclamp			
0	LS00	Tool Clamp			

IN, COM, PAGE: See section B.2.2.1 for detail.

FIGURE B-3 DI/DO TABLE BODY DETAIL

B.2.2.1 IN, COM, and Page

Figure B-4 explains the IN, COM, and Page columns data.

COM: The “source” connector is shown at top (i.e. C24L (CMA)) with common voltage pin numbers listed below.

IN: lists the pin number for the signal's “high leg”.

Page: The page number and coordinate where the signal and circuit are found in the schematics.

IN	COM	Page
A20	C24L (CMA) A24 B24	13/6D
B20		13/6D
A21		-
B21		201/6D
A22		201/5D
B22		201/4D
A23		201/3D
B23		201/2D

FIGURE B-4 COM, PIN, AND PAGE DETAIL

B.3 Abbreviations

Table B-1 lists the abbreviations used in the DI/DO Tables.

TABLE B-1 DIAGNOSTIC TABLE ABBREVIATIONS

Abbreviation	Meaning
Clog.	Clogged
CONN.	Connection
Cool.	Coolant
Contr. or Cont	Controller
INTLK.	Interlock
J Box	Junction Box
Mag.	Magazine
OPE. or Ope.	Operator’s
PNL or Pnl.	Panel
Ref.	Reference
RTR. or Rtr.	Rotor
S.H.	Spindle Head
Temp.	Temperature

B.4 Diagnostic (I/O) Tables

The communication signals between the PMC software and the MT (Machine Tool) are specific to the Makino V55 with Makino PRO 3 control.

To simplify usage, the DI/DO Tables are divided into sections by signal types, as shown below:

9.3.1 MT (MACHINE TOOL) DATA INPUT SIGNALS

9.3.2 MT (MACHINE TOOL) DATA OUTPUT SIGNALS

9.3.3 OP (OPERATOR PANEL) DATA INPUT SIGNALS

9.3.4 OP (OPERATOR PANEL) DATA OUTPUT SIGNALS

More Detail

1. Signal names preceded by an asterisk (*) are normally held “high”
2. “Latching alarms” are used by the PMC. When an alarm is generated, the PMC prevents the interrupted action from continuing, when the fault is corrected. If no [RETRY] is provided, the alarm must be RESET before automatic operation is permitted to continue.
3. When using the PRO 3 diagnostic screen, use the following information to find the proper PMC address groups:
   - X INPUT (MT to PMC) – The PMC address number is equal to the Diagnostic address number. So X00.0 = Diagnostic # 000, Bit # 0 and X20.6 = Diagnostic # 020, Bit # 6.
   - Y OUTPUT (PMC to MT) – Add 200 to the Y PMC address to get the Diagnostic address number. So Y20.6 = Diagnostic # 220, Bit # 6.
4. To search a specific DIAGNOSTIC ADDRESS, select the proper screen “page” – DI or DO – using the [PAGE SELECT] soft key, key in the DIAGNOSTIC ADDRESS number to be searched, and press the [NO. SEARCH] soft key.
5. For a list of the CNC – PMC DI/DO signals or BMI (Basic Machine Interface), refer to the CNC Maintenance Manual.
6. For more information on the PMC address and data bit display, see Chapter 4.

NOTES:

SKETCHES:

B.4.1 MT (Machine Tool) Data Input Signals

This section contains the DI signals from the MT to the PMC. These signals are denoted by the PMC address X.

- When using the CUSTOM diagnostic screen, use the following information to find the proper PMC address groups:
  - X INPUT (MT to PMC) – PMC address number is equal to the Diagnostic address number.

EXAMPLE: X05.6 = Diagnostic # 005, Bit # 6.

- To search a specific DIAGNOSTIC ADDRESS, select the proper screen “page” – DI or DO – using the [PAGE SELECT] soft key, key in the DIAGNOSTIC ADDRESS number to be searched, and press the [NO. SEARCH] soft key.

DATA INPUT

Diagnostic: 000		PMC Address X00	I/O Unit Group 0/Base 0/Slot 1		
Bit	**Signal Name**	**Meaning**	**IN**	**COM**	**Page**
7	RCH2	Spindle Rotor Condition Confirm 2	A20	C24L (CMA) A24 B24	13/6D
6	RCH1	Spindle Rotor Condition Confirm 1	B20		13/6D
5	-	-	A21		-
4	LS1340	Union Abnormal Detection	B21		201/6D
3	LS602	Tool Not Detection	A22		201/5D
2	LS601	Tool Fitting Confirm	B22		201/4D
1	LS01	Tool Unclamp	A23		201/3D
0	LS00	Tool Clamp	B23		201/2D

Diagnostic: 001		PMC Address X01	I/O Unit Group 0/Base 0/Slot 1		
Bit	**Signal Name**	**Meaning**	**IN**	**COM**	**Page**
7	MZRC	ATC Magazine CCW Switch	A14	C24L (CMB) A18 B18	282/3D 281/3D
6	MZR	ATC Magazine CW Switch	B14		282/3D 281/3D
5	ATCMAS	ATC Manual Switch	A15		282/2D 281/2D
4	-	-	B15		-
3	-	-	A16		-
2	LS748	ATC Shutter OPEN	B16		271/3D
1	LS747	ATC Shutter CLOSE	A17		271/3D
0	LS99	Magazine Side Tool Exist Confirm	B17		271/2D 275/3D

DATA INPUT

Diagnostic: 002		PMC Address X02	I/O Unit Group 0/Base 0/Slot 1		
Bit	**Signal Name**	**Meaning**	**IN**	**COM**	**Page**
7	LS1307	Through Tool Coolant Flow Switch	A8	C24L (CMC) A12 B12	251/4D
6	LS1319	Coolant Tank Empty Detection	B8		251/5D
5	LS181	Nozzle Coolant Flow Switch	A9		251/2D
4	LS193	Through Spindle Coolant Flow Switch	B9		251/3D
3	MS11C	Work Piece Washing Gun On	A10		223/6D
2	LS905	Main Air Pressure Switch	B10		191/2D
1	LS170	Oil Temp. Contr. Flow Switch	A11		241/4D
0	LS173	Oil Temp Contr. Clog Detection	B23		241/5D

Diagnostic: 003		PMC Address X03	I/O Unit Group 0/Base 0/Slot 1		
Bit	**Signal Name**	**Meaning**	**IN**	**COM**	**Page**
7	ALSXYP	Auto Grease Injector Pressure Up	A2	C24L (CMD) A6 B6	601/7D
6	-	-	B2		-
5	-	-	A3		-
4	MOPMUL	Main Operator Panel Mode Unlock	B3		61/7E
3	IRKEY	S/G Door Interlock Cancel Key Switch	A4		361/4D
2	LS942	ATC Door Interlock	B4		363/4D 364/4D
1	LS912	S/G Door Interlock	A5		361/3D
0	SGLKS	S/G Door Interlock Mode	B5		361/3D

DATA INPUT

Diagnostic: 004		PMC Address X04	I/O Unit Group 0/Base 0/Slot 2		
Bit	**Signal Name**	**Meaning**	**IN**	**COM**	**Page**
7	SKIP	Skip Signal	A20	C24L (CMA) A24 B24	481/3E
6	-	-	B20		-
5	LCREV	Lift Up Chip Conveyor Reverse Switch	A21		411/3D
4	LCFWD	Lift Up Chip Conveyor Forward Switch	B21		411/2D
3	LCMAS	Lift Up Chip Conveyor Manual Switch	A22		411/2D
2	(XAE)	-	B22		-
1	(YAE)	-	A23		-
0	(ZAE)	-	B23		-

Diagnostic: 005		PMC Address X05	I/O Unit Group 0/Base 0/Slot 2		
Bit	**Signal Name**	**Meaning**	**IN**	**COM**	**Page**
7	-	-	A14	C24L (CMB) A18 B18	-
6	H5S	Axis Select 5th - Axis	B14		122/5D
5	H4S	Axis Select 4th - Axis	A15		122/5D
4	HZS	Axis Select Z - Axis	B15		122/5D
3	HYS	Axis Select Y - Axis	A16		122/4D
2	HXS	Axis Select X - Axis	B16		122/4D
1	MP2S`	Handle Pulse Rate X100	A17		122/4D
0	MP1S	Handle Pulse Rate X10	B17		122/3D

DATA INPUT

Diagnostic: 006		PMC Address X06	I/O Unit Group 0/Base 0/Slot 2		
Bit	**Signal Name**	**Meaning**	**IN**	**COM**	**Page**
7	OCALM	Oil Controller Alarm	A8	C24L (CMC A12 B12	244/5D
6	OCFIS	Oil Controller Filter Sign	B8		244/4D
5	DAIN	Oil Controller Data Input	A9		244/4D
4	OCACK	Oil Controller Data ACK	B9		244/4D
3	OCD13	Oil Controller Input Data 3	A10		244/3D
2	OCD12	Oil Controller Input Data 2	B10		244/3D
1	OCD11	Oil Controller Input Data 1	A11		244/3D
0	OCD10	Oil Controller Input Data 0	B11		244/2D

Diagnostic: 007		PMC Address X07	I/O Unit Group 0/Base 0/Slot 2		
Bit	**Signal Name**	**Meaning**	**IN**	**COM**	**Page**
7	-	-	A2	C24L (CMD) A6 B6	-
6	-	-	B2		-
5	-	-	A3		-
4	-	-	B3		-
3	-	-	A4		-
2	DTCH4	4^{th} Axis Detach	B4		341/4D
1	L152	4^{th} Axis Unclamp	A5		341/4D
0	L151	4^{th} Axis Clamp	B5		341/3D

DATA INPUT

Diagnostic: 008		PMC Address X08	I/O Unit Group 0/Base 0/Slot 3		
Bit	**Signal Name**	**Meaning**	**IN**	**COM**	**Page**
7	CPTP	Inside Cabinet Protector Trip	A20	C24L (CMA) A24 B24	171/6D 172/1D
6	CBTP	Inside Cabinet Breaker Trip	B20		171/5D
5	EMI	Emergency Stop	A21		152/7B
4	*ESP	Emergency Stop Signal	B21		162/2D
3	-	-	A22		
2	-	-	B22		
1	-	-	A23		
0	-	-	B23		

Diagnostic: 009		PMC Address X09	I/O Unit Group 0/Base 0/Slot 3		
Bit	**Signal Name**	**Meaning**	**IN**	**COM**	**Page**
7	-	-	A14	C24L (CMB) A18 B18	-
6	*DEC7	ATC Magazine B Ref. Slow Down	B14		275/2D
5	*DEC6	ATC Magazine A Ref. Slow Down	A15		271/5D 275/2D
4	-	-	B15		-
3	*DEC4	4^{th} Axis Reference Slow Down	A16		341/2D
2	*DECZ	Z Axis Reference Slow Down	B16		181/4D
1	*DECY	Y Axis Reference Slow Down	A17		181/3D
0	*DECX	X Axis Reference Slow Down	B17		181/2D

DATA INPUT

Diagnostic: 010		PMC Address X010	I/O Unit Group 0/Base 0/Slot 3		
Bit	**Signal Name**	**Meaning**	**IN**	**COM**	**Page**
7	-	-	A8	C24L (CMC) A12 B12	-
6	-	-	B8		-
5	-	-	A9		-
4	LS1339	Through Spindle Filter Clog Detection	B9		251/7D
3	-	-	A10		-
2	OT2Z	Z - Axis OT2	B10		161/4D
1	OT2Y	Y - Axis OT2	A11		161/3D
0	OT2X	X - Axis OT2	B11		161/2D

Diagnostic: 011		PMC Address X011	I/O Unit Group 0/Base 0/Slot 3		
Bit	**Signal Name**	**Meaning**	**IN**	**COM**	**Page**
7	MSALB	Battery Error	A2	C24L (CMD) A6 B6	492/5D
6	MSALA	Reception Alarm	B2		492/4D
5	TH19	Oil Mist Collector Thermal Alarm	A3		192/2D 193/2D
4	AIRAL	Air Drier Alarm	B3		192/6D
3	THOL2	Coolant Thermal Alarm	A4		231/2D
2	OMAL2	Coolant Temp. Controller Alarm	B4		242/4D
1	THOL1	Oil Temp. Cont. Thermal Alarm	A5		231/6D
0	OMAL1	Spindle Oil Temp. Controller Alarm	B5		241/3D

DATA INPUT

Diagnostic: 012		PMC Address X012	I/O Unit Group 0/Base 0/Slot 7		
Bit	**Signal Name**	**Meaning**	**IN**	**COM**	**Page**
7	LS56	Pallet Unclamp	A20	C24L (CMA) A24 B24	298/2D
6	LS55	Pallet Clamp	B20		298/2D
5	LS136	S/G Shutter Middle Pos.	A21		297/3D
4	LS131	S/G Shutter Open.	B21		297/2D
3	LS130	S/G Shutter Close	A22		297/2D
2	LS971	Pallet Fitting Confirm	B22		296/4D
1	LS322	Pallet Lift Confirm	A23		296/3D
0	LS321	Pallet Down Confirm	B23		296/2D

Diagnostic: 013		PMC Address X013	I/O Unit Group 0/Base 0/Slot 7		
Bit	**Signal Name**	**Meaning**	**IN**	**COM**	**Page**
7	LS1073	Tool Clamp	A14	C24L (CMB) A18 B18	263/4D
6	LS1070	Motor Stop & ATC Arm Reference Zone	B14		263/3D
5	IV1ALM	Inverter 1 Alarm	A15		263/2D
4	MGSELB	ATC Magazine B Select	B15		282/5D
3	LS320	Table Side Pallet Confirm	A16		296/5D
2	LS761	Pot Unclamp	B16		273/3D
1	LS760	Pot Clamp	A17		273/2D
0	LS668	Shifter Pot Confirm	B17		273/2D

DATA INPUT

Diagnostic: 014		PMC Address X014	I/O Unit Group 0/Base 0/Slot 7		
Bit	**Signal Name**	**Meaning**	**IN**	**COM**	**Page**
7	LS682	Shifter 3 Retract	A8	C24L (CMB) A18 B18	273/6D
6	LS681	Shifter 3 Advance	B8		273/6D
5	LS680	Shifter 2 Retract	A9		273/5D
4	LS679	Shifter 2 Advance	B9		273/5D
3	LS751	Shifter 1 Retract	A10		273/4D
2	LS750	Shifter 1 Advance	B10		273/3D
1	LS669B	Magazine B Pot Confirm	A11		275/6D
0	LS669A	Magazine A Pot Confirm	B11		275/6D

Diagnostic: 015		PMC Address X015	I/O Unit Group 0/Base 0/Slot 7		
Bit	**Signal Name**	**Meaning**	**IN**	**COM**	**Page**
7	USDI8	User DI-8	A2	C24L (CMD) A6 B6	511/6D
6	USDI7	User DI-7	B2		511/6D
5	USDI6	User DI-6	A3		511/5D
4	USDI5	User DI-5	B3		511/5D
3	USDI4	User DI-4	A4		511/4D
2	USDI3	User DI-3	B4		511/3D
1	USDI2	User DI-2	A5		511/3D
0	USDI1	User DI-1	B5		511/2D

DATA INPUT

Diagnostic: 020		PMC Address X016	I/O Unit Group 1/Base 0/Slot 1		
Bit	**Signal Name**	**Meaning**	**IN**	**COM**	**Page**
7	LS105	Arm 2 Advance	46	C24L (CMA) 49 50	294/6B
6	LS1761	Arm 2 Slow Down	30		294/5D
5	LS1714	Arm 2 Middle Pos.	47		294/5D
4	LS104	Arm 2 Retract	31		294/4D
3	LS101	Arm 1 Advance	15		294/4D
2	LS1760	Arm 1 Slow Down	48		294/3D
1	LS1711	Arm 1 Middle Pos.	32		294/3D
0	LS100	Arm 1 Retract	16		294/3D

Diagnostic: 021		PMC Address X021	I/O Unit Group 1/Base 0/Slot 1		
Bit	**Signal Name**	**Meaning**	**IN**	**COM**	**Page**
7	LS111	Pallet 2 Confirm	42	C24L (CMB) 29 45	295/3D
6	LS110	Pallet 1 Confirm	10		295/2D
5	-	-	43		-
4	-	-	27		-
3	-	-	11		-
2	-	-	44		-
1	-	-	28		-
0	-	-	12		-

DATA INPUT

Diagnostic: 022		PMC Address X022	I/O Unit Group 1/Base 0/Slot 1		
Bit	**Signal Name**	**Meaning**	**IN**	**COM**	**Page**
7	-	-	37	C24L (CMC) 40 41	-
6	PCINS2	Pallet 2 Load Switch	22		301/6D
5	PDYPB2	Pallet 2 Ready Switch	38		301/6D
4	PCOUTS	Pallet Unload Switch	23		301/3D
3	PCINS1	Pallet 1 Load Switch	6		301/3D
2	PDYPB1	Pallet 1 Ready Switch	39		301/3D
1	PCSPC	APC Stop Switch	24		301/2D
0	PCMAS	APC Manual	7		301/2D

Diagnostic: 023		PMC Address X023	I/O Unit Group 1/Base 0/Slot 1		
Bit	**Signal Name**	**Meaning**	**IN**	**COM**	**Page**
7	LS966	APC Door Interlock	33	C24L (CMD) 21 36	365/4C
6	-	-	1		-
5	-	-	34		-
4	-	-	19		-
3	-	-	2		-
2	-	-	35		-
1	-	-	20		-
0	IV2ALM	Inverter 2 Alarm	3		293/3D

NOTES:

SKETCHES:

B.4.2 MT (Machine Tool) Data Output Signals

This section contains the DO signals from the MT to the PMC. These signals are denoted by the PMC address Y.

- When using the CUSTOM diagnostic screen, use the following information to find the proper PMC address groups:
  - Y OUTPUT (PMC to MT) – Add 200 to the PMC address to obtain the Diagnostic address number.

EXAMPLE: Y05.6 = Diagnostic # 205, Bit # 6.

- To search a specific DIAGNOSTIC ADDRESS, select the proper screen “page” – DI or DO – using the [PAGE SELECT] soft key, key in the DIAGNOSTIC ADDRESS number to be searched, and press the [NO. SEARCH] soft key.

DATA OUTPUT

Diagnostic: 200		PMC Address Y00	I/O Unit Group 0/Base 0/Slot 4		
Bit	**Signal Name**	**Meaning**	**IN**	**COM**	**Page**
7	SL905	Main Air ON	A20	C24 HA (CMA) A24 B24	191/3B
6	RCHP	Spindle Rotor Change	B20		13/2B
5	-	-	A21		-
4	-	-	B21		-
3	POUT1	Auto Power Out	A22		171/3B
2	OT	OT Release	B22		162/4A
1	SA	Servo Ready	A23		171/2B
0	MA	NC Ready	B23		171/2B

Diagnostic: 201		PMC Address Y01	I/O Unit Group 0/Base 0/Slot 4		
Bit	**Signal Name**	**Meaning**	**IN**	**COM**	**Page**
7	HAMOD	Handle Mode	A14	C24 HA (CMB) A18 B18	24/2B
6	-	-	B14		-
5	SL1310	Through Spindle Suction Solenoid	A15		222/5B
4	SL1309	Through Spindle Cool./Air Union Drain	B15		203/6B
3	SL1308	Through Spindle Coolant/Air Union BU	A16		203/6B
2	SL1306	Through Spindle Coolant/ Side Solenoid	B16		222/4B
1	SL09	Spindle Cleaning Air	A17		202/3B
0	SL01	Tool Unclamp	B17		202/2B

DATA OUTPUT

Diagnostic: 202		PMC Address Y02	I/O Unit Group 0/Base 0/Slot 4		
Bit	**Signal Name**	**Meaning**	**IN**	**COM**	**Page**
7	MS15	Through Tool Coolant	A8	E24 HA (CMC) A12 B12	221/4B
6	MS10	Ceiling Shower Coolant	B8		221/4B
5	MS8	Through Spindle Coolant	A9		222/3B
4	-	-	B9		-
3	-	-	A10		-
2	-	-	B10		-
1	MS19	Oil Mist Collector	A11		192/3B 193/3B
0	MS2	Nozzle Coolant	B11		221/3B

Diagnostic: 203		PMC Address Y03	I/O Unit Group 0/Base 0/Slot 4		
Bit	**Signal Name**	**Meaning**	**IN**	**COM**	**Page**
7	SL192	Through Spindle Coolant/Air Change	A2	E24 HA (CMD) A6 B6	203/4B
6	SL189	Through Tool Air	B2		203/3B
5	SL181	Air Blow	A3		203/2B
4	SGWP	S/G Wiper On	B3		421/2A
3	MS7R	Scraper Conveyor CCW	A4		224/2B
2	MS7F	Scraper Conveyor CW	B4		224/2B
1	-	-	A5		-
0	-	-	B5		-

DATA OUTPUT

Diagnostic: 204		PMC Address Y04	I/O Unit Group 0/Base 0/Slot 4		
Bit	**Signal Name**	**Meaning**	**IN**	**COM**	**Page**
7	-	-	A20	C24 HB (CMA) A24 B24	-
6	-	-	B20		-
5	-	-	A21		-
4	SL171	Spindle Oil Pressure Air	B21		202/5B
3	MS102	Ball-Screw Cooling Pump	A22		221/2B
2	MS101	Spindle Oil Cont Joint Pump	B22		221/2B
1	MS83	Spindle Oil Cont Suction Pump	A23		221/1B
0	OMON	Spindle Oil Temp. Controller On	B23		241/7B

Diagnostic: 205		PMC Address Y05	I/O Unit Group 0/Base 0/Slot 5		
Bit	**Signal Name**	**Meaning**	**IN**	**COM**	**Page**
7	SL711B	ATC Shutter Open	B14	(CMB) A18 B18	281/6B 282/6B
6	SL711A	ATC Shutter Close	A15		272/3B
5	-	-	B15		272/2B
4	-	-	A16		-
3	-	-	B16		-
2	-	-	A17		-
1	-	-	B17		-
0	SL711B	ATC Shutter Open	B14		-

DATA OUTPUT

Diagnostic: 206		PMC Address Y06	I/O Unit Group 0/Base 0/Slot 5		
Bit	**Signal Name**	**Meaning**	**IN**	**COM**	**Page**
7	-	-	A8	C24 HB (CMC) A12 B12	-
6	-	-	B8		-
5	DAOUT	Spindle Oil Controller Data Output	A9		243/4B
4	OCSTB	Spindle Oil Controller Data STB	B9		243/3B
3	OCD03	Spindle Oil Controller Output Data 3	A10		243/3B
2	OCD02	Spindle Oil Controller Output Data 2	B10		243/3B
1	OCD01	Spindle Oil Controller Output Data 1	A11		243/2B
0	OCD00	Spindle Oil Controller Output Data 0	B11		243/2B

Diagnostic: 207		PMC Address Y07	I/O Unit Group 0/Base 0/Slot 5		
Bit	**Signal Name**	**Meaning**	**IN**	**COM**	**Page**
7	MLT	S/G Illumination	A2	C24 HB (CMD) A6 B6	401/2B
6	ALSXYR	Auto Grease Injector CCW	B2		601/5B
5	ALSXYF	Auto Grease Injector CW	A3		601/5B
4	-	-	B3		-
3	BZ1	Buzzer 1	A4		391/5B
2	PTL3	Signal Light 3	B4		391/3B
1	PTL2	Signal Light 2	A5		391/3B
0	PTL1	Signal Light 1	B5		391/3B

DATA OUTPUT

Diagnostic: 208		PMC Address Y08	I/O Unit Group 0/Base 0/Slot 6		
Bit	**Signal Name**	**Meaning**	**IN**	**COM**	**Page**
7	LCRUNL	L/C Run Lamp	A20	C24 HC (CMA) A24 B24	411/6B
6	LCALML	L/C Alarm Lamp	B20		411/6B
5	LCMAL	L/C Manual Lamp	A21		411/5B
4	MS6R	Lift Up Chip Conveyor CCW	B21		221/6B
3	MS6F	Lift Up Chip Conveyor CW	A22		221/6B
2	MS6A	Filter Opposite Flow Cleaning	B22		221/5B
1	SL913	ATC Door Unlock	A23		363/5B 364/5B
0	SGOP	S/G Door Unlock Mode	B23		361/5B

Diagnostic: 209		PMC Address Y09	I/O Unit Group 0/Base 0/Slot 6		
Bit	**Signal Name**	**Meaning**	**IN**	**COM**	**Page**
7	-	-	A14	C24 HC (CMB) A18 B18	-
6	-	-	B14		-
5	SL193	REV Cleaning Air	A15		491/5B
4	OPPON	Probe Power On	B15		492/6B
3	SL301	Stylus Cleaning Air	A16		482/2B
2	M33X	Tool Length Measuring Circuit Check	B16		481/6B
1	M32X	Tool Length Measuring Mode	A17		481/5B
0	NMSMD	Not Measuring Mode	B17		481/5B

DATA OUTPUT

Diagnostic: 210		PMC Address Y10	I/O Unit Group 0/Base 0/Slot 6		
Bit	**Signal Name**	**Meaning**	**IN**	**COM**	**Page**
7	STLR	Auto Running	A8	C24 HC (CMC) A12 B12	451/2B
6	SAR	Spindle Running	B8		451/2B
5	-	-	A9		-
4	-	-	B9		-
3	-	-	A10		-
2	-	-	B10		-
1	-	-	A11		-
0	SL150	4^{th}-Axis Unclamp	B11		341/6B

Diagnostic: 211		PMC Address Y11	I/O Unit Group 0/Base 0/Slot 6		
Bit	**Signal Name**	**Meaning**	**IN**	**COM**	**Page**
7	-	-	A2	(CMD) A6 B6	-
6	-	-	B2		-
5	-	-	A3		-
4	-	-	B3		-
3	-	-	A4		-
2	-	-	B4		-
1	-	-	A5		-
0	-	-	B5		-

DATA OUTPUT

Diagnostic: 212		PMC Address Y12	I/O Unit Group 0/Base 0/Slot 8		
Bit	**Signal Name**	**Meaning**	**IN**	**COM**	**Page**
7	-	-	A20	E24 HD (CMA) A24 B24	-
6	-	-	B20		-
5	SL130B	S/G Shutter Open	A21		297/6B
4	SL130A	S/G Shutter Close	B21		297/5B
3	SL61B	Pallet Lift	A22		298/6B
2	SL61A	Pallet Down	B22		298/5B
1	SL52	Locate Pin Cleaning Air	A23		298/5B
0	SL51	Pallet Unclamp	B23		298/4B

Diagnostic: 213		PMC Address Y13	I/O Unit Group 0/Base 0/Slot 8		
Bit	**Signal Name**	**Meaning**	**IN**	**COM**	**Page**
7	SL759a	Shifter 3 Retract	B14	(CMB) A18 B18	274/5B
6	SL758a	Shifter 2 Retract	A15		274/4B
5	SL759b	Shifter 3 Advance	B15		274/5B
4	SL758b	Shifter 2 Advance	A16		274/4B
3	SL750b	Shifter 1 Advance	B16		274/3B
2	SL750a	Shifter 1 Retract	A17		274/3B
1	SL754	Pot Unclamp	B17		274/2B
0	SL759a	Shifter 3 Retract	B14		274/5B

DATA OUTPUT

Diagnostic: 214		PMC Address Y14	I/O Unit Group 0/Base 0/Slot 8		
Bit	**Signal Name**	**Meaning**	**IN**	**COM**	**Page**
7	MGBKB	ATC Magazine B Brake Release	A8	C24 HD (CMC) A12 B12	26/7A
6	MGBKA	ATC Magazine A Brake Release	B8		26/6A
5	-	-	A9		-
4	-	-	B9		-
3	-	-	A10		-
2	IV1RST	Inverter 1 Reset	B10		262/4B
1	IV1RM	Inverter 1 Velocity 2	A11		262/3B
0	IV1RH	Inverter 1 Velocity 1	B11		262/3B

Diagnostic: 215		PMC Address Y15	I/O Unit Group 0/Base 0/Slot 8		
Bit	**Signal Name**	**Meaning**	**IN**	**COM**	**Page**
7	USDO8	User DO-8	A2	C24 HD (CMD) A6 B6	512/6B
6	USDO7	User DO-7	B2		512/6B
5	USDO6	User DO-6	A3		512/5B
4	USDO5	User DO-5	B3		512/5B
3	USDO4	User DO-4	A4		512/3B
2	USDO3	User DO-3	B4		512/3B
1	USDO2	User DO-2	A5		512/2B
0	USDO1	User DO-1	B5		512/2B

DATA OUTPUT

Diagnostic: 220		PMC Address Y20	I/O Unit Group 1/Base 0/Slot 2		
Bit	**Signal Name**	**Meaning**	**IN**	**COM**	**Page**
7	-	-	46	C24 HD (CMA) 49 50	-
6	-	-	30		-
5	-	-	47		-
4	-	-	31		-
3	-	-	15		-
2	-	-	48		-
1	MS97	Arm 2 Drive	32		292/6B
0	MS96	Arm 1 Drive	16		292/6B

Diagnostic: 221		PMC Address Y21	I/O Unit Group 1/Base 0/Slot 2		
Bit	**Signal Name**	**Meaning**	**IN**	**COM**	**Page**
7	-	-	42	E24 HD (CMB) 29 45	-
6	-	-	10		-
5	-	-	43		-
4	IV2RST	Inverter 2 Reset	27		292/3B
3	IV2RM	Inverter Velocity 2	11		292/3B
2	IV2RH	Inverter Velocity 1	44		292/3B
1	IV2STR	Inverter 2 Reverse	28		292/2B
0	IV2STF	Inverter 2 Forward	12		292/2B

DATA OUTPUT

Diagnostic: 222		PMC Address Y22	I/O Unit Group 1/Base 0/Slot 2		
Bit	**Signal Name**	**Meaning**	**IN**	**COM**	**Page**
7	-	-	37	C24 HF (CMC) 40 41	-
6	PCINL2	Pallet 2 Load Switch Lamp	22		302/6B
5	PRDY2	Pallet 2 Ready Switch Lamp	38		302/5B
4	PCOUTL	Pallet Unload Switch Lamp	23		302/3B
3	PCINL1	Pallet 1 Load Switch Lamp	6		302/3B
2	PRDY1	Pallet 1 Ready Switch Lamp	39		302/3B
1	PCSPL	APC Stop Switch Lamp	24		302/2B
0	PCMAL	APC Manual Switch Lamp	7		302/2B

Diagnostic: 223		PMC Address Y23	I/O Unit Group 1/Base 0/Slot 2		
Bit	**Signal Name**	**Meaning**	**IN**	**COM**	**Page**
7	SL914	APC Door Unlock	33	C24 HF (CMD) 21 36	365/5C
6	-	-	1		-
5	-	-	34		-
4	-	-	19		-
3	-	-	2		-
2	-	-	35		-
1	-	-	20		-
0	-	-	3		-

NOTES:

SKETCHES:

B.4.3 OP (Operator Panel) Data Input Signals

This section contains the DI signals from the Operator panel. These signals are denoted by the PMC address X.

- When using the CUSTOM diagnostic screen, use the following information to find the proper PMC address groups:
  - X INPUT (OP to PMC) – PMC address number is equal to the Diagnostic address number.

EXAMPLE: X96.6 = Diagnostic # 096, Bit # 6.

- To search a specific DIAGNOSTIC ADDRESS, select the proper screen “page” – DI or DO – using the [PAGE SELECT] soft key, key in the DIAGNOSTIC ADDRESS number to be searched, and press the [NO. SEARCH] soft key.

DATA INPUTS

Diagnostic: 096		PMC Address X96	I/O Unit Operator Panel		
Bit	**Signal Name**	**Meaning**	**IN**	**COM**	**Page**
7	HS	Handle Mode	21	COM 18	112/4D
6	JS	Jog Mode	3		112/4D
5	RTS	Rapid Mode	35		112/4D
4	ZRNS	Reference Mode	20		112/3D
3	EDTS	Editor Mode	2		112/3D
2	MEMS	Memory Mode	34		112/2D
1	DS	MDI Mode	19		112/2D
0	TS	Tape Mode	1		112/2D

Diagnostic: 097		PMC Address X97	I/O Unit Operator Panel		
Bit	**Signal Name**	**Meaning**	**IN**	**COM**	**Page**
7	OTRS	OT Release	6	COM 18	113/3D
6	JOG+	JOG(+)	38		113/2D
5	JOG-	JOG(-)	23		113/2D
4	5AXS	5-TH Axis Select	5		112/7D
3	4AXS	4-TH Axis Select	37		112/6D
2	ZAXS	Z-Axis Select	22		112/6D
1	YAXS	Y-Axis Select	4		112/5D
0	XAXS	X-Axis Select	36		112/5D

DATA INPUTS

Diagnostic: 098		PMC Address X98	I/O Unit Operator Panel		
Bit	Signal Name	Meaning	IN	COM	Page
7	FXS03	Flexible Switch 03 (Scraper)	9	COM 18	113/6D
6	FXS02	Flexible Switch 02 (Nozzle Coolant)	41		113/6D
5	FXS01	Flexible Switch 01 (Coolant ON/OFF)	8		113/5D
4	STS	Cycle Start	40		113/5D
3	SPS	Feed Hold	25		113/4D
2	SPST	Spindle Start	7		113/4D
1	SPSP	Spindle Stop	39		113/3D
0	KEYI	Memory Protect Release	24		113/3D

Diagnostic: 099		PMC Address X99	I/O Unit Operator Panel		
Bit	Signal Name	Meaning	IN	COM	Page
7	STUCS	Tool Unclamp	44	COM 18	114/6D
6	FXS09	Flexible Switch 09 (Handle Interrupt)	11		114/6D
5	FXS08	Flexible Switch 08 (Single Block)	43		114/6D
4	FXS07	Flexible Switch 07 (Optional Stop)	27		114/5D
3	FXS06	Flexible Switch 06 (Dry Run)	10		114/5D
2	FXS05	Flexible Switch 05 (Light)	42		114/5D
1	FXS04	Flexible Switch 04 (Power Off)	26		114/4D
0	FXS09	Flexible Switch 09 (Handle Interrupt)	11		114/4D

DATA INPUTS

Diagnostic: 100		PMC Address X100	I/O Unit Operator Panel		
Bit	**Signal Name**	**Meaning**	**IN**	**COM**	**Page**
7	-	-	31	COM 18	-
6	-	-	14		-
5	JVM	Jog Feed Rate Switch Inhibit	46		115/3D
4	JV16I	Jog Feed Rate Switch 16	30		115/3D
3	JV8I	Jog Feed Rate Switch 8	13		115/3D
2	JV4I	Jog Feed Rate Switch 4	45		115/2D
1	JV2I	Jog Feed Rate Switch 2	29		115/2D
0	JV1I	Jog Feed Rate Switch 1	12		115/1D

Diagnostic: 101		PMC Address X101	I/O Unit Operator Panel		
Bit	**Signal Name**	**Meaning**	**IN**	**COM**	**Page**
7	POFFS	Power Off	50	COM 18	114/3D
6	-	-	17		-
5	-	-	49		-
4	-	-	16		-
3	ROVM	Rapid Override Switch Inhibit	48		115/6D
2	ROV4I	Rapid Override Switch 4	32		115/5D
1	ROV2I	Rapid Override Switch 2	15		115/5D
0	ROV1I	Rapid Override Switch 1	47		115/4D

DATA INPUTS

Diagnostic: 102		PMC Address X102	I/O Unit Operator Panel		
Bit	Signal Name	Meaning	IN	COM	Page
7	-	-	21	COM 18	-
6	-	-	3		-
5	FVM	Feed Override Switch Inhibit	35		116/4D
4	FV16I	Feed Override Switch 16	20		116/3D
3	FV8I	Feed Override Switch 8	2		116/3D
2	FV4I	Feed Override Switch 4	34		116/2D
1	FV2I	Feed Override Switch 2	19		116/2D
0	FV1I	Feed Override Switch 1	1		116/2D

Diagnostic: 103		PMC Address X103	I/O Unit Operator Panel		
Bit	Signal Name	Meaning	IN	COM	Page
7	-	-	6	COM 18	-
6	-	-	38		-
5	-	-	23		-
4	-	-	5		-
3	SOVM	Spindle Override Switch Inhibit	37		116/7D
2	SOV4I	Spindle Override Switch 4	22		116/5D
1	SOV2I	Spindle Override Switch 2	4		116/5D
0	SOV1I	Spindle Override Switch 1	36		116/5D

NOTES:

SKETCHES:

B.4.4 OP (Operator Panel) Data Output Signals

This section contains the DO signals from the Operator panel. These signals are denoted by the PMC address Y.

- When using the CUSTOM diagnostic screen, use the following information to find the proper PMC address groups:
  - Y OUTPUT (PMC to OP) – Add 200 to the PMC address to obtain the Diagnostic address number.

EXAMPLE: Y96.6 = Diagnostic # 296, Bit # 6.

- To search a specific DIAGNOSTIC ADDRESS, select the proper screen “page” – DI or DO – using the [PAGE SELECT] soft key, key in the DIAGNOSTIC ADDRESS number to be searched, and press the [NO. SEARCH] soft key.

DATA OUTPUT

Diagnostic: 296		PMC Address Y96	I/O Unit Operator Panel		
Bit	**Signal Name**	**Meaning**	**IN**	**COM**	**Page**
7	-	-	21	C24H COM 18	-
6	-	-	3		-
5	-	-	35		-
4	-	-	20		-
3	-	-	2		-
2	MCREF	Machine Reference	34		114/3B
1	WRNL	Warning	19		114/2B
0	ALML	Alarm	1		114/2B

Diagnostic: 297		PMC Address Y97	I/O Unit Operator Panel		
Bit	**Signal Name**	**Meaning**	**IN**	**COM**	**Page**
7	-	-	6	C24H COM 18	-
6	-	-	38		-
5	-	-	23		-
4	-	-	5		-
3	-	-	37		-
2	-	-	22		-
1	-	-	4		-
0	-	-	36		-

DATA OUTPUT

Diagnostic: 298		PMC Address Y98	I/O Unit Operator Panel		
Bit	**Signal Name**	**Meaning**	**IN**	**COM**	**Page**
7	FXL03	Flexible Switch 03 (Scraper)	9	C24H COM 18	113/6B
6	FXL02	Flexible Switch 02 (Nozzle Coolant)	41		113/6B
5	FXL01	Flexible Switch 01 (Coolant ON/OFF)	8		113/5B
4	STLO	Cycle Start	40		113/5B
3	SPLO	Feed Hold	25		113/4B
2	SPSTL	Spindle Start	7		113/4B
1	-	-	39		-
0	POFFL	Power Off	24		114/3B

Diagnostic: 299		PMC Address Y99	I/O Unit Operator Panel		
Bit	**Signal Name**	**Meaning**	**IN**	**COM**	**Page**
7	STUCL	Tool Unclamp	44	COM1 18	114/6B
6	-	-	28		-
5	FXL09	Flexible Switch 09 (Handle Interrupt)	11		114/6B
4	FXL08	Flexible Switch 08 (Single Block)	43		114/5B
3	FXL07	Flexible Switch 07 (Optional Stop)	27		114/5B
2	FXL06	Flexible Switch 06 (Dry Run)	10		114/5B
1	FXL05	Flexible Switch 05 (Light)	42		114/4B
0	FXL04	Flexible Switch 04 (Power Off)	26		114/4B

NOTES:

SKETCHES: