8 Shimming

8.1 Personnel Requirements

Personnel Requirements	Preliminary Reqs	Procedure	Finalization
2	Included in Procedure	10 hours (excluding field stability check)	Included in Procedure

8.2 Overview

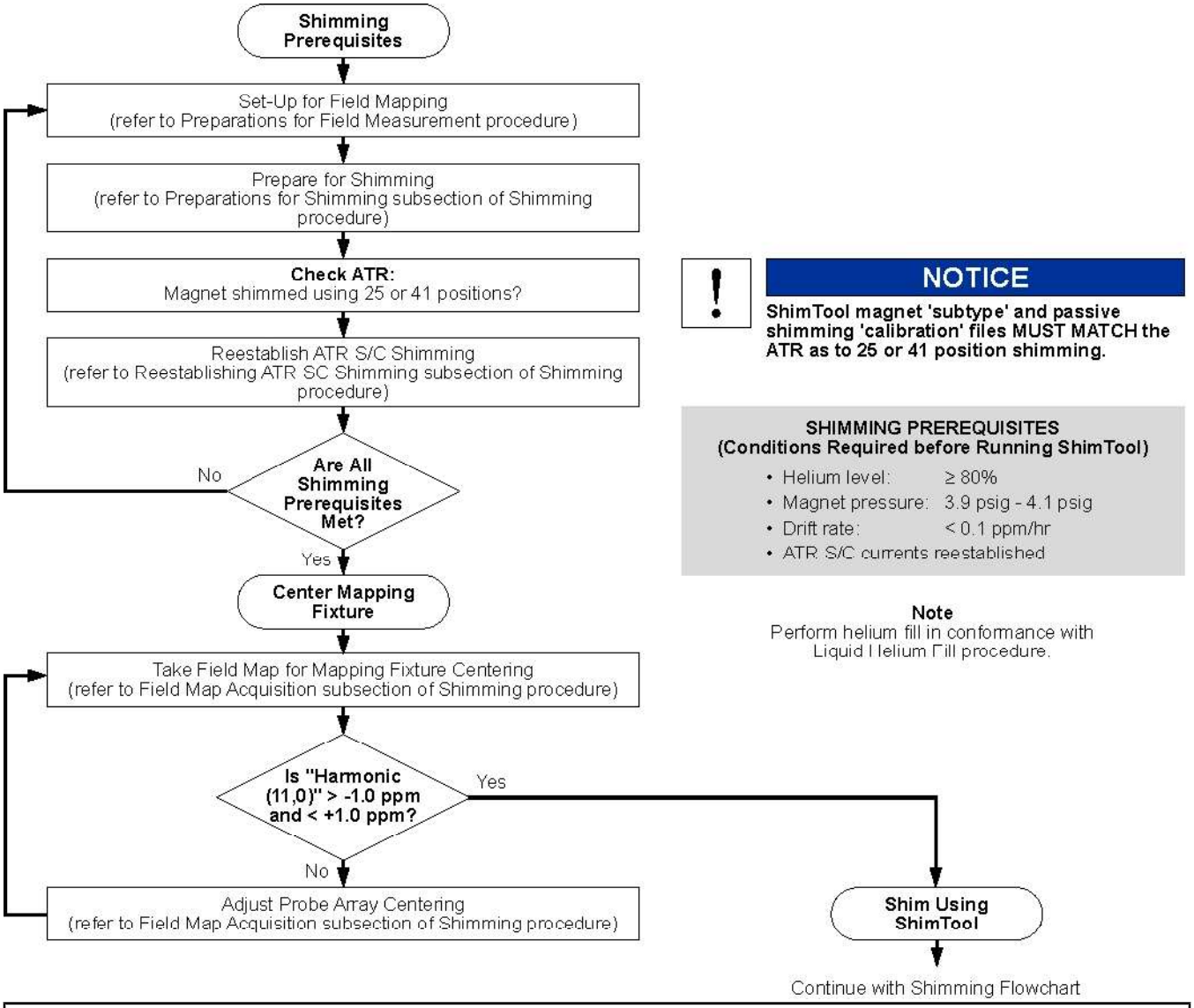
Shimming is the process of measuring the magnet's field over a fixed volume and then calculating and installing active (superconducting) and passive (steel) shims to improve field homogeneity. The factory shimming results for LCC300 magnets are in the Acceptance Test Report (ATR) shipped with the magnet. On-site shimming is performed to compensate for unequal distribution of room steel that is affecting field homogeneity. Additional shimming may be required following any significant environmental changes near the magnet. It is important to perform shimming after the magnet is sited and ramped and the magnetic field stabilized.

NOTE:

- After factory superconducting (S/C) shim currents are reapplied to the magnet, use ShimTool software to calculate any additional passive and S/C (active) shimming required on site. Flowcharts of shimming prerequisites and the shimming process are shown in Illustration 3-95 and Illustration 3-96.
- Allow the magnet to stabilize to <0.1 ppm/hr. main field drift before shimming. This will take 12 hours. Other commissioning functions can be performed during this time.
- The minimum helium level to start shimming is 80%.

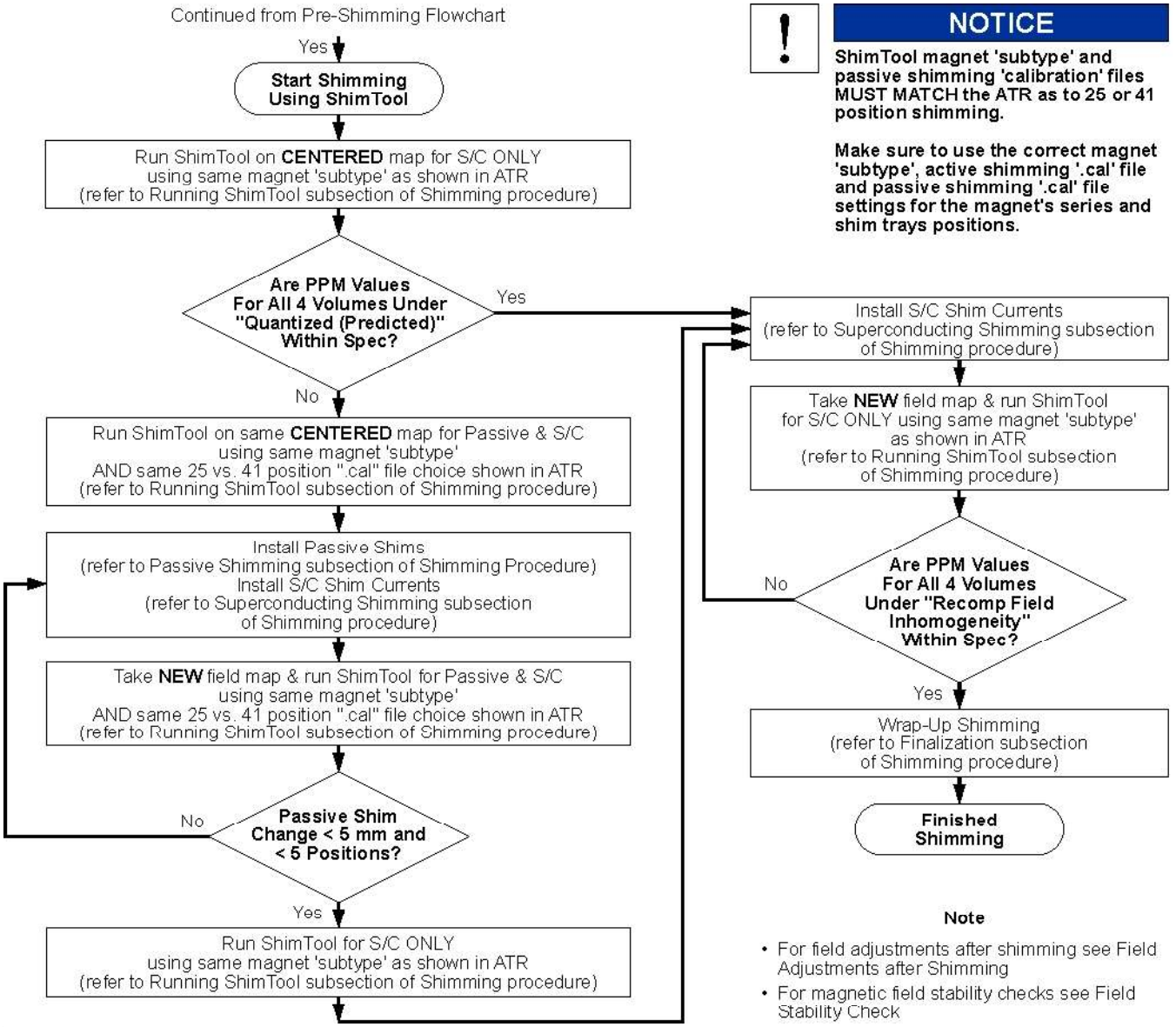
NOTE: Always use the **most recent** revision of GE ShimTool Software CD, 5102783. The LCC300 Shimming procedure stated here includes shimming of WB Series LCC300 magnets, which requires 5102783 Revision 6, minimum.

Illustration 3-95: Pre-Shimming Flowchart



Procedures Referenced	
Liquid Helium Fill	Section 8.4.1, Preparations for Shimming
Preparations for Field Measurement	Section 8.4.2, Re-establishing ATR SC Shim Currents
	Section 8.4.3.1, Field Map Acquisition

Illustration 3-96: Shimming Flowchart



Procedures Referenced	
Section 8.4.3, Running ShimTool	Field Adjustment after Shimming
Section 8.4.4, Passive Shimming	Chapter 4, Field Stability Check
Section 8.4.5, Superconducting Shimming	
Finalization, Step 1	

8.3 Preliminary Requirements

8.3.1 Tools and Test Equipment

Item	Qty	Effectivity	Part#	Manufacturer
3.0T Warning Sign & Label Kit	1	-	2379494	-
Portable Oxygen Monitor	1 kit per person	-	2287000	-
Cryogen Safety Wear Kit	1 set per person	-	46-271137G1	-
Nonabsorbent protective clothing (long sleeve shirt and pants)	1 pair per person	-	-	-
Nonferrous Safety Shoes	1	-	-	-
Brass Master Padlock with Brass Shackle	1	-	46-194427P320	-
Brass Master Transition Padlock	1 pkg. of 25	-	2387081	-
Black & White on Red Lockout Tag	1	-	46-194427P322	-
Transition LOTO Tag	1	-	46-194427P313	-
Line Cord Plug Cover, Plugs ≤3 in. wide x ≤ 5.875 in. long (76 mm x 149 mm), Cords ≤1.25 in. (31 mm) diameter	1	-	46-194427P321	-
Shim Power Supply	1	-	46-260777G3	-
750 Amp Ramp Cable Kit 2135435 or 1000 Amp Ramp Cable Kit with Ground 2353394	1	-	2135435 or 2353394	-
Shim Cable Kit (if not already ordered with the magnet)	1	-	2135558	-
MetroLab Teslameter Kit	1	-	46-251865G4	-

Item	Qty	Effectivity	Part#	Manufacturer
No. 5 MetroLab Probe (included in MetroLab Teslameter Kit 46-251865G4)	1	-	46-255839P104	-
No. 6 MetroLab Probe (included in MetroLab Teslameter Kit 46-251865G4)	1	-	2295525-5	-
LCC300 Shim Camera Kit	1	-	2386028	-
GE ShimTool Software CD, 5102783 (included in LCC300 Shim Camera Kit, 2386028). NOTE: Use the most recent revision. Shimming WB Series LCC300 magnets requires Revision 6, minimum.	1	-	5102783	-
LCC300 Passive Shimming Kit (includes LCC300 Field Mapping Fixture 2380758)	1	-	2386029	-
LCC300 Field Passive Shim Kit	1	-	2385710	-
LCC300 Passive Shimming Pull Assist Kit	1	-	5104145	-
Titanium Tool Kit, Basic Set 5113258, Titanium Tool Kit, Installation Set 5112581 or other non-ferromagnetic tools (magnets with magnetic fields >1.5T)	1	-	5113258 or 5112581	-
HDx Service Platform: Can use Universal Service Ladder/Platform 2319156 if service space ≥30 inches (762 mm)	1	-	5155291 (or 2319156)	-

Item	Qty	Effectivity	Part#	Manufacturer
Service Methods documentation for the magnet/enclosures (available through the Common Document Library at www.gehealthcare.com or through your local GE Healthcare Service Representative)	1	-	-	-

8.3.2 Consumables

Item	Qty	Effectivity	Part#	Manufacturer
Optional field-supplied item: 10 mil thick flexible plastic sheets (x-ray film, Mylar or equivalent), 10 in. x 14 in. (250 mm x 350 mm), minimum. Must be free of sharp edges and bent corners.	1	-	-	-

8.3.3 Safety

DANGER

POTENTIAL FATAL INJURY!

MAKE SURE TO REVIEW AND FULLY UNDERSTAND ALL SUPERCONDUCTING MAGNET PORTIONS OF CHAPTER 1, MR MAGNET - SAFETY REQUIREMENTS BEFORE SHIMMING THE MAGNET.

DANGER

POTENTIAL FATAL INJURY!

MAKE SURE TO FULLY COMPLY WITH ALL REQUIRED ITEMS FOR SHIMMING IN THE 'MAGNET & CRYOGEN SERVICE SAFETY REQUIREMENTS' SUBSECTION OF CHAPTER 1, MR MAGNET - SAFETY REQUIREMENTS BEFORE AND WHILE SHIMMING THE MAGNET.

DANGER

POTENTIAL FATAL INJURY!

HAVE ALL WORK ASSISTANTS OR WORK OBSERVERS COMPLY WITH THE 'BUDDY SYSTEM REQUIREMENTS & CERTIFICATION' SUBSECTION OF CHAPTER 1, MR MAGNET - SAFETY REQUIREMENTS BEFORE SHIMMING THE MAGNET.

WARNING

ASPHYXIATION HAZARD!
THE SHIMMING PROCEDURE GENERATES ODORLESS, COLORLESS HELIUM GAS THAT DISPLACES OXYGEN IN THE AIR.
MAKE SURE MAGNET ROOM VENT EXHAUST FAN IS ON BEFORE SHIMMING THE MAGNET.

WARNING

ELECTRICAL SHOCK HAZARD
CONTACT WITH CONNECTORS LEADING TO AN ENERGIZED POWER SUPPLY CAN CAUSE ELECTRICAL SHOCK.
FOLLOW LOCKOUT/TAGOUT PROCEDURES WHILE MAKING ELECTRICAL CONNECTIONS TO A MAIN POWER SUPPLY OR A SHIM POWER SUPPLY. (SEE CHAPTER 1, OSHA LOCKOUT-TAGOUT.)

NOTICE

Verify that Magnet Monitor is on and operational. If using proprietary Magnet Monitor software, verify that Magnet Monitor Pressure Control is enabled and operational.

NOTICE

Moving articles or equipment in the Magnet Room may affect field readings. Do not move articles or equipment in the Magnet Room while adjusting shim currents.

NOTICE

ONLY use nonmagnetic tools when working in the Magnet Room.

8.3.4 Required Conditions

Condition	Reference	Effectivity
Make sure the area is secure and that **all** required Warning Signs are posted to meet the safety requirements stated in the following document before starting the Shimming procedure.	Chapter 1, MR Magnet - Safety Requirements	-

Condition	Reference	Effectivity
The removal of some magnet enclosure components may be required to complete the Shimming procedure. Refer to the appropriate document below *and* the appropriate Service Methods documentation (available through the Common Document Library at www.gehealthcare.com or your local GE Healthcare Service Representative) before continuing with the Shimming procedure if cover removal is required.	Chapter 5, Upper and Side Enclosure Removal (Wide Open Enclosures)	-
(continued)	Chapter 5, Introduction to HDe & HDx Enclosures	-
Verify that the magnet helium level is ≥80%. Fill the magnet in conformance with the document below to make sure the helium level is at this level before shimming.	Liquid Helium Fill	-
Verify that the magnet's magnetic field drift rate is <0.1 ppm/hr. and that the Magnet Monitor is on and operational. If using proprietary Magnet Monitor software, verify that the Magnet Monitor Pressure Control is enabled and operational. Verify that the magnet pressure is steady at 3.9 to 4.1 psig, both conditions in conformance with Section 8.4.1.3, Field Stability Check subsection below before starting Section 8.4.3, Running ShimTool.	Shimming	-
Make sure to reestablish the SC Shim Currents stated in the magnet's Acceptance Test Report (ATR) in conformance with Section 8.4.2, Reestablishing ATR SC Shim Currents, before starting Section 8.4.3, Running ShimTool.	Shimming	-
Make sure the magnet room exhaust fan is on and operational before starting the Shimming procedure.	-	-
Make sure the magnet room door is propped open before starting the Shimming procedure.	-	-

8.4 Procedure

8.4.1 Preparations for Shimming

8.4.1.1 Initial Preparations

NOTE: Section 8.4.1, Preparations for Shimming, must be completed before shimming the magnet.

1. Prepare for field mapping in conformance with Preparations for Field Measurement before shimming if not already done.

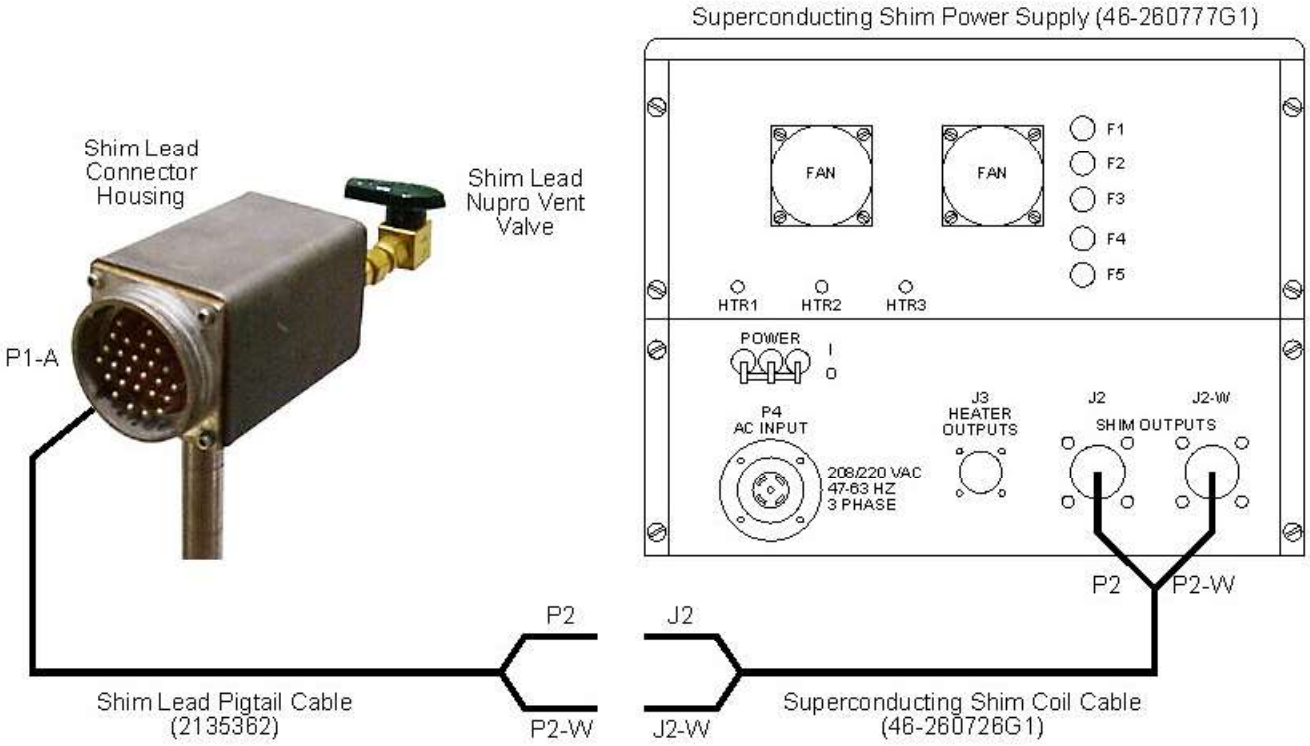
2. Allow the magnet to stabilize to <0.1 ppm/hr. main field drift before shimming. This will take 12 hours. Other commissioning functions can be performed during this time.

3. Verify that the magnet helium level is ≥80%. Fill the magnet in conformance with Liquid Helium Fill to make sure the helium level is ≥80% before continuing.

8.4.1.2 Shim Coil Power Supply Connections

1. Verify that the Shim Lead Pigtail Cable (2135362) is connected to P1-A on the Shim Lead Assembly in conformance with the *Superconducting Shim Coil Power Supply Connections to Magnet* subsection of Connections for Ramping and Shimming. (See the illustration below.)

Illustration 3-97: Shim Power Supply Connections to P1-A



2. Make sure the Shim Lead Assembly is engaged in conformance with Shim Lead Engagement and Disengagement.

3. Open the NuPro Shim Lead Vent Valve to increase the Shim Leads' ability to carrying current.

NOTICE

Do not connect input power to the Superconducting Shim Coil Power Supply until it is verified that ALL current controls are set to zero (turned fully counterclockwise, CCW) and the supply is turned off.
Connecting the Superconducting Shim Coil Harness to the magnet when the Superconducting Shim Coil Power Supply is turned on may cause irreparable damage to the vapor-cooled shim leads.

NOTICE

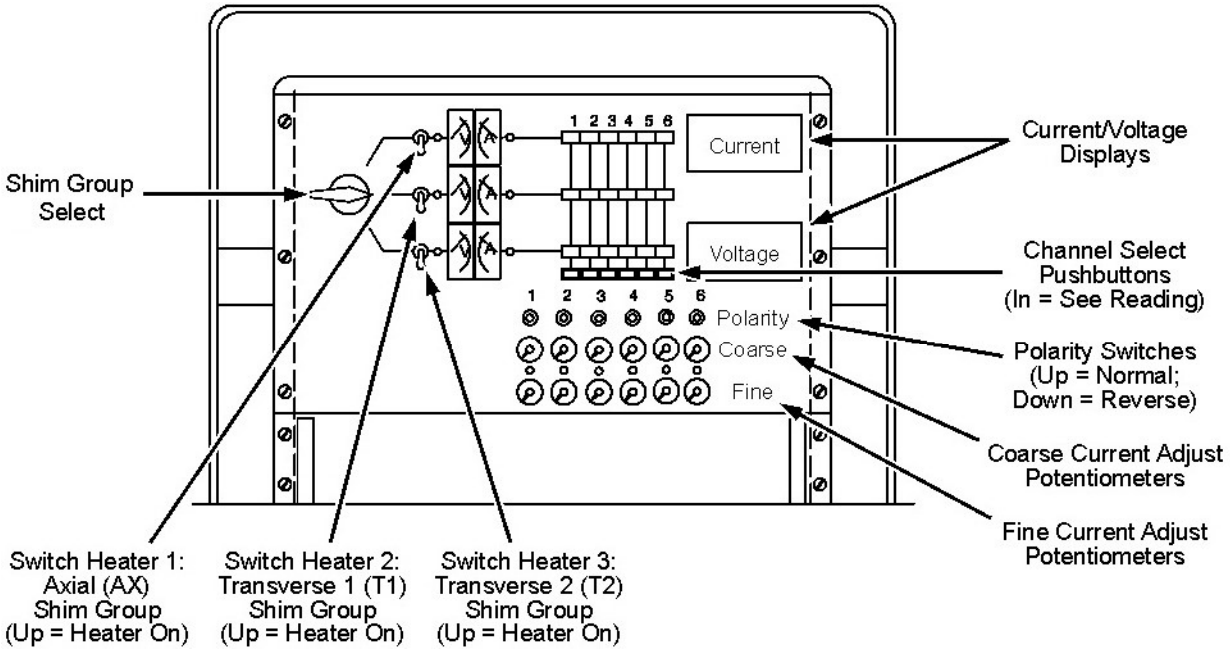
Equipment damage is possible if heater currents are not set correctly.

4. Remove LOTO and connect input power to the Superconducting Shim Coil Power Supply. Make sure the Heater Currents are: T1 = 610 mA ±5 mA, T2 = 610 mA ±5 mA and Axial = 710 mA ±10 mA. (See Section 4 of the vendor's service manual for details.)

   NOTE: Always check the ATR for any possible magnet-specific current settings.

5. After sufficient cooling of the Shim Lead Assembly, verify that all six shim power supply channels operate at both positive and negative 250 mA polarities for the Axial, Transverse 1 and Transverse 2 shim groups. (See the illustration below.)

Illustration 3-98: Shim Power Supply Controls (Front Panel)



⚠WARNING

ELECTRICAL SHOCK HAZARD
CONTACT WITH CONNECTORS LEADING TO AN ENERGIZED POWER SUPPLY CAN CAUSE ELECTRICAL SHOCK.
FOLLOW LOCKOUT/TAGOUT PROCEDURES WHILE MAKING ELECTRICAL CONNECTIONS TO THE SHIM POWER SUPPLY.

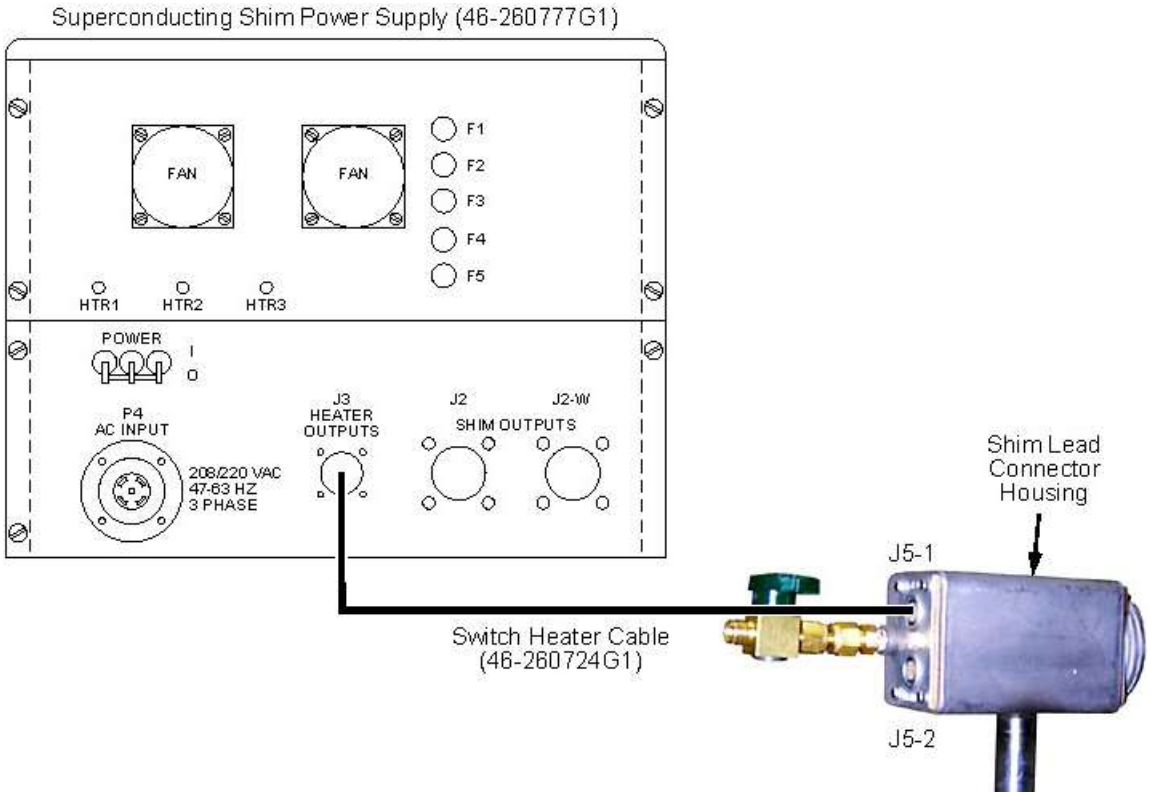
6. Disconnect and LOTO the input power to the Shim Coil Power Supply. Verify that no voltage is present by using a DVM or equivalent measuring device.

7. Verify that connectors P2 and P2W on Superconducting Shim Coil Cable 46-260726G1 (Run 603) are connected to the J2 and J2-W Shim Output connectors on the back of the Power Supply Cabinet, MS7-A1. (See Illustration 3-97.)

8. Verify that connectors J2 and J2-W on the other end of Superconducting Shim Coil Cable 46-260726G1 are connected to the Shim Lead Pigtail Cable 2135362. (See Illustration 3-97.)

9. Connect P703 on Switch Heater Cable 46-260724G1 (Run 604) to connector J3 on the back of the Superconducting Shim Coil Power Supply Cabinet, MS7-A1. (See the illustration below.)

Illustration 3-99: Shim Power Supply Connections to J5-1



NOTICE

Connect only one Heater Wire Harness to the Shim Lead Assembly.

10. Verify that connector P5 on the Switch Heater Cable (Run 604) is connected to connector J5-1 or J5-2 on the Shim Lead Assembly. (See Illustration 3-99.)

8.4.1.3 Field Stability Check

This check requires 12 hours between the first measurement and the second.

1. Verify that magnet pressure is 4.0 psig ±0.1 psig:
   - Initial on-site shimming - Turn on the T1, T2, and Axial heaters as required to increase magnet pressure to 4.0 psig ±0.1 psig.
   - If any currents loaded (reshimming) - Adjust magnet pressure to 4.0 psig ±0.1 psig using Magnet Monitor.

NOTICE

Do not turn on the Superconducting Shim Coil Power Supply until it is verified that ALL current controls are set to zero (turned fully counterclockwise).

NOTE: Make sure the Teslameter is on at least one hour before taking either measurement to ensure Teslameter stabilization.

2. Remove LOTO and connect input power to the S/C Shim Coil Power Supply and turn on (I) all Shim Coil Switch Heaters for five (5) minutes to dump any residual shim currents.
3. Turn off (O) the Switch Heaters. Allow 3 to 5 minutes for the switch heaters to go persistent before continuing with Step 4.
4. Disconnect the Heater Cable (P703) from the Shim Coil Power Supply.
5. Turn off the Shim Coil Power Supply.

⚠WARNING

ELECTRICAL SHOCK HAZARD
CONTACT WITH CONNECTORS LEADING TO AN ENERGIZED POWER SUPPLY CAN CAUSE ELECTRICAL SHOCK.
FOLLOW LOCKOUT/TAGOUT PROCEDURES WHILE MAKING ELECTRICAL CONNECTIONS TO THE SHIM POWER SUPPLY.

6. Disconnect and lockout/tagout input power to the Shim Coil Power Supply. Verify that no voltage is present by using a DVM or equivalent measuring device.
7. Measure and record the magnetic field (center frequency), “Frequency 1”.

NOTE: The Frequency 1 measurement should be taken as soon after ramping as possible.

NOTICE

Do not move the probe between the first and second measurements.
Do not move or rearrange any articles or equipment in or near the exam room during the test.

8. After 12 hours repeat Step 2 through Step 7. Measure and record this as “Frequency 2”.

9. Verify that the magnet has stabilized (0.1 ppm/hr. maximum drift) by using this formula:

$$\text{Drift Rate (ppm/hr)} = \frac{(\text{Freq 1} - \text{Freq 2}) \times 10^6}{(\text{Freq 1}) \times N}$$

$$\text{Drift Rate (Hz/hr)} = \frac{(\text{Freq 1} - \text{Freq 2})}{N}$$

Where:
Freq 1 = Initial Reading (Hz)
Freq 2 = Reading (Hz) after N Hours
N = Number Hours between Readings

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8.4.1.4 Magnet Pressure, Helium Level and Coldhead Supercon Shield

1. On the Magnet Monitor:

NOTICE

Shimming is affected by magnet pressure. Make sure the Magnet Monitor Pressure Controller is functioning properly and that magnet pressure is steady at 3.9 to 4.1 psig before starting shimming procedure.

   a. Check magnet pressure. Make sure it is maintained within the 3.9 to 4.1 psig range when taking maps of the magnetic field.

   b. Verify that the magnet helium level is ≥80%. Fill the magnet in conformance with Liquid Helium Fill to make sure the helium level is ≥80% before continuing.

2. Turn the Cryocooler off for 10 minutes. This will quench the Supercon Shield around the Coldhead.

   NOTE: This only needs to be done before the initial shimming, but not between each shimming iteration.

8.4.1.5 Field Camera Set-Up Using ShimTool

NOTICE

Always use the most recent revision of GE ShimTool Software CD, 5102783. The LCC300 Shimming procedure stated here includes shimming of WB series LCC300 magnets, which requires 5102783 Revision 6, minimum.

1. Connect the Shim Camera to the PC's COM port. Make sure all connections are secure.

2. Install the Mapping Fixture's Probe Array in conformance with Preparations for Field Measurement if not already installed.

3. If the most recent version of GE ShimTool Software CD, 5102783 is **not** installed on the computer being used:

    a. Insert the CD into the computer, automatically launching the installation program. Select the operating system, either Windows 2000 or Windows XP, for the computer in use when asked. The CD should automatically install all ShimTool files at **`D:\MRshim`** (Windows XP) or **`C:\MRshim`** (Windows 2000).

    b. Create a subdirectory for this magnet's **`.map, .cur`** and **`.shm`** files inside the **`D:\MRshim`** (Windows XP) or **`C:\MRshim`** (Windows 2000) directory where ShimTool was installed.

        - For W Series magnets, name the subdirectory **`W0####0`**, substituting the magnet's serial number for the ####. For WB Series magnets, name the directory **`WB####0`**.
        - Add extra zeros as necessary to ensure the subdirectory name is seven characters/numbers long. For example, the subdirectory for the W Series Magnet 22 should be **`W000220`**.

    c. Copy the magnet's ATR shim file from the ATR floppy to the PC to the subdirectory created in Step 3.b.

4. Double-click on the CoronaShim icon or **`ShimTool25C.exe`** in the ShimTool directory in Windows Explorer.

5. When the screen shown in Illustration 3-100 displays:

    a. Verify that the entry beside the word **`Series:`** matches the **W** or **WB** of the magnet to be shimmed.

    b. Type **`W`** into the box beside **`Test Cell:`**.

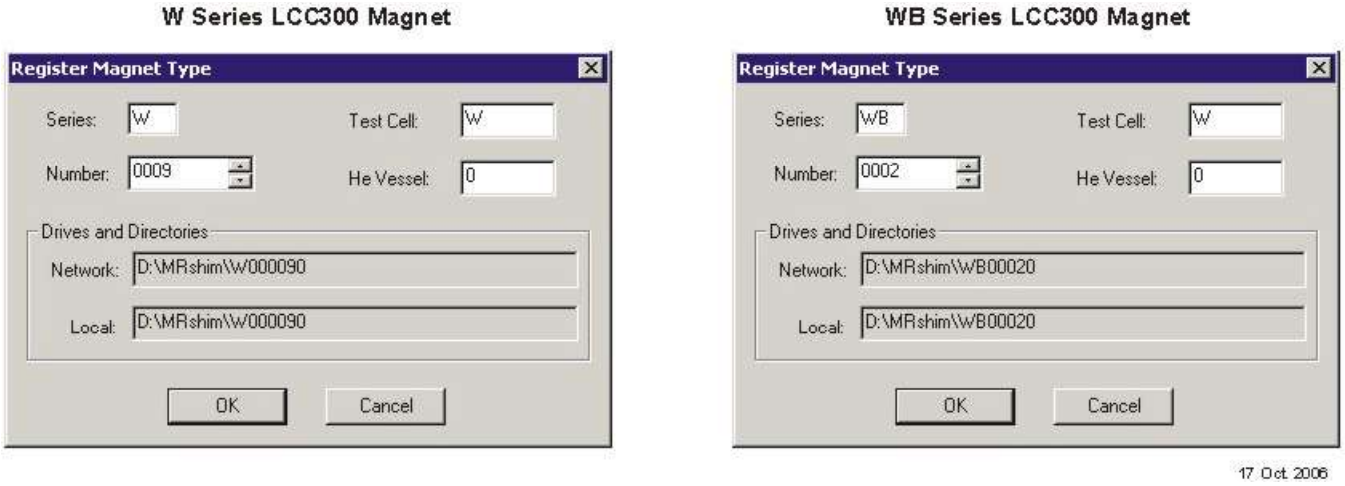
        NOTE: Use “W” for all shimming done at a customer site.

    c. Adjust the number displayed beside **`Number:`** to the serial number of the magnet to be shimmed.

    d. Click [OK].

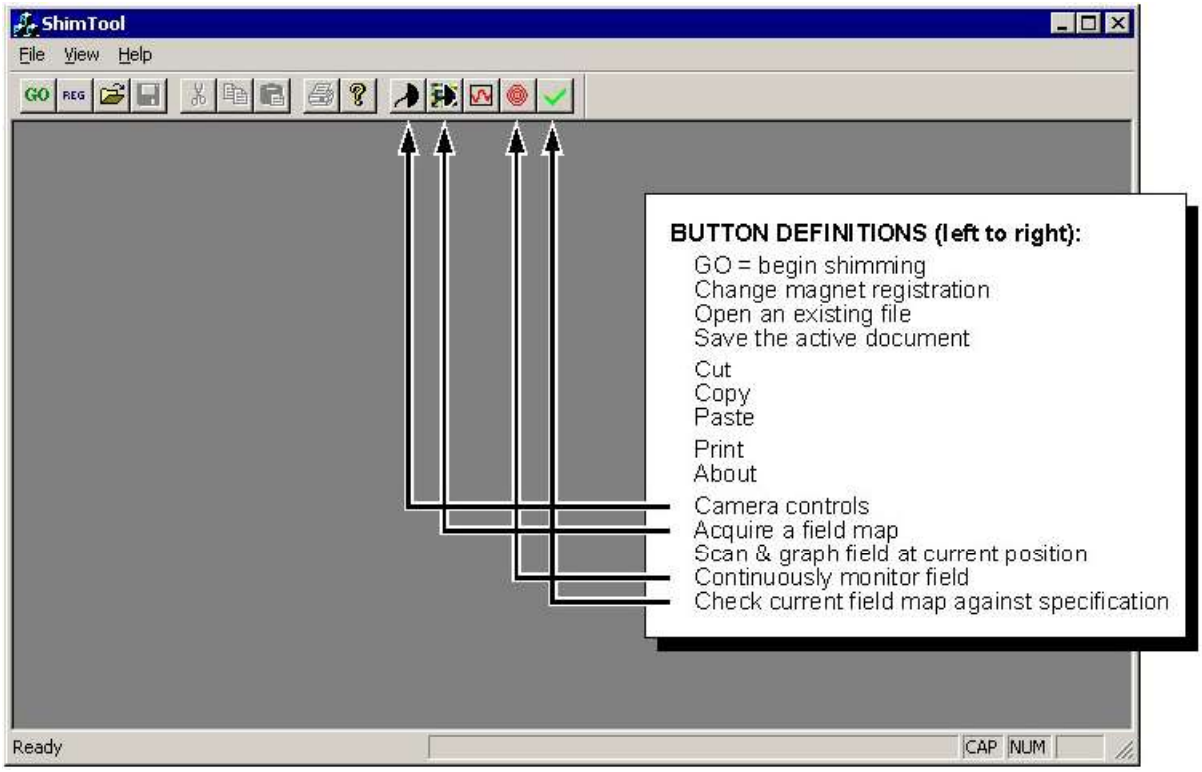
    NOTE: If a subdirectory for storing all **`.map, .cur`** and **`.shm`** files was not manually created in Step 3.b, ShimTool will create one automatically at **`D:\MRshim\W0####0`** for W Series magnets or at **`D:\MRshim\WB####0`** for WB Series magnets. (### represents the serial number selected.)
    Windows XP installations use **`D:\`** drive; Windows 2000 installations use **`C:\`** drive.

Illustration 3-100: Register Magnet Type Screen



6. Click the [Camera Controls] button (fifth button from right) when the screen shown in Illustration 3-101 displays.

Illustration 3-101: ShimTool Main Screen Button Definitions

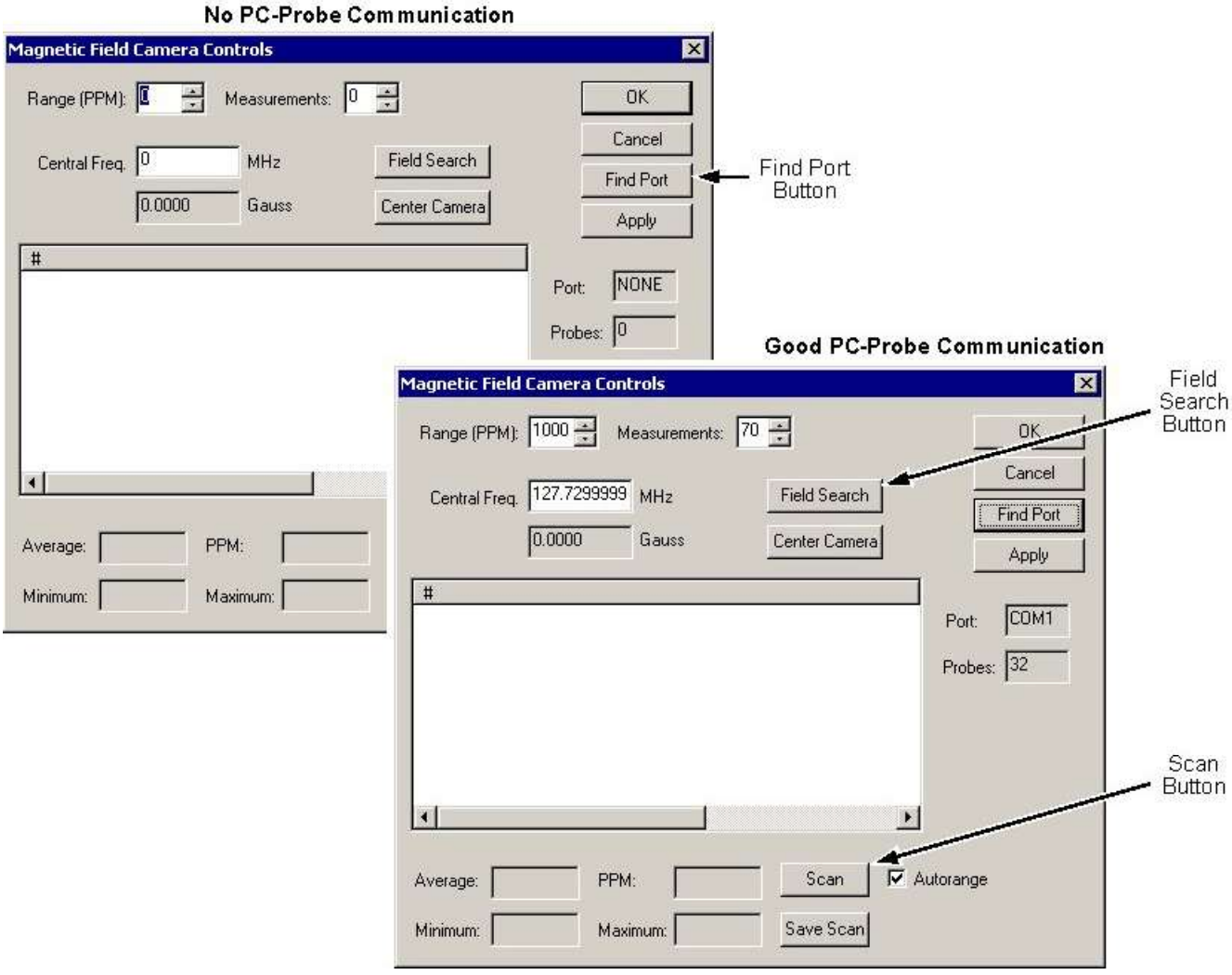


7. Verify that the *Magnetic Field Camera Controls* window (shown in Illustration 3-102) displays a **`Center Freq:`** of 127.7 mHz (rounded).

NOTE: If the program did not find a camera attached to the PC's COM port (as in the upper left example in Illustration 3-102:

- Verify that power to the camera is turned on and that all connections between the probe array, camera and PC are secure, then
- Click the [Find Port] button to reestablish camera to PC communications.
- Exit any programs that Windows Task Manager (accessed by pressing <Ctrl> + <Alt> + <Delete>) reports are running on the PC besides ShimTool and Windows Explorer shows.

Illustration 3-102: Magnet Field Camera Controls: PC-Probe Communications



8. Choose an option on the *Magnetic Field Camera Controls* screen shown in Illustration 3-102:

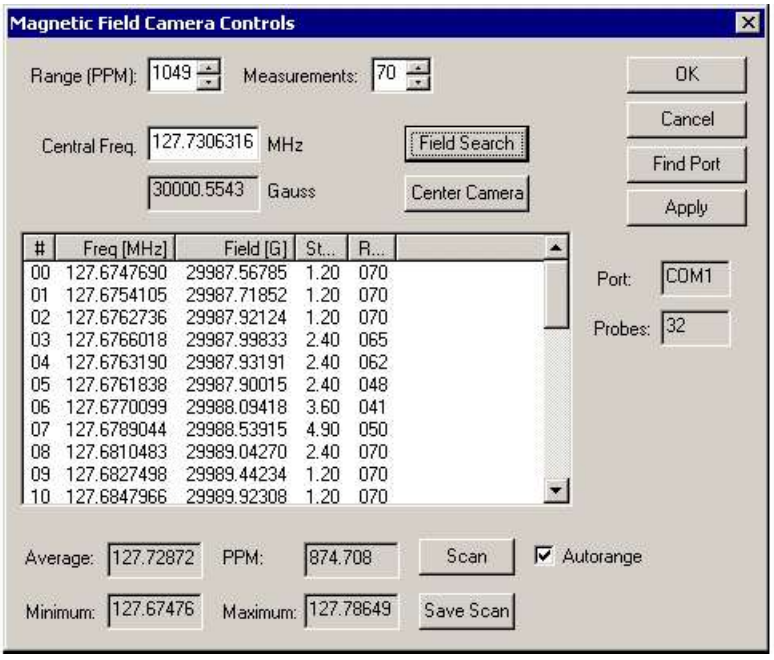
   a. Click the [Field Search] button to automatically find the center frequency of the magnet and update the **`Center Freq:`** displayed. (See Illustration 3-103.) An initial listing of (left to right) probe number, frequency in mHz, magnetic field strength in Gauss,

standard deviation in Gauss and measurement count readings from each probe in the array is also displayed in the text box.

NOTE: The measurement counts should all read close to the number displayed beside **`Measurements:`** at the top of the screen.

b. Click the [Scan] button to verify probe functioning by updating the scrolling text box.

Illustration 3-103: Magnet Field Camera Controls with Field Search Button



9. Select [OK] to finish camera setup and close the *Magnetic Field Camera Controls* screen.

10. Continue with Section 8.4.2, Re-establishing ATR SC Shim Currents.

8.4.2 Re-establishing ATR SC Shim Currents

DANGER

POTENTIAL FATAL INJURY!

MAKE SURE TO REVIEW AND FULLY UNDERSTAND ALL SUPERCONDUCTING MAGNET PORTIONS OF CHAPTER 1, MR MAGNET - SAFETY REQUIREMENTS BEFORE STARTING THE SHIMMING PROCEDURE.

WARNING

ASPHYXIATION HAZARD!
THE SHIMMING PROCEDURE GENERATES ODORLESS, COLORLESS HELIUM GAS THAT DISPLACES OXYGEN IN THE AIR.
MAKE SURE MAGNET ROOM VENT EXHAUST FAN IS ON BEFORE STARTING THE SHIMMING PROCEDURE.

CAUTION

Potential Magnet Quench

The magnet may quench if the Nupro Valve on the Shim Lead is closed or the Shim Lead is not cold.

Make sure the Nupro Valve is fully open and the valve is frosted before slowly engaging the Shim Lead. Do not remove the Shim Lead's Orifice Cap that controls helium gas flow. Always engage/disengage the Shim Lead in conformance with Shim Lead Engagement and Disengagement.

NOTICE

Make sure that the shim power supply is calibrated in conformance with the vendor's manual and that the shim heater currents are set as below before use.

- Transverse 1 Shim Heater Current: 610 mA ±5 mA
- Transverse 2 Shim Heater Current: 610 mA ±5 mA
- Axial Shim Heater Current: 710 mA ±10 mA

NOTICE

Before turning on the shim coil power supply and applying shim currents, make sure the following conditions exist to prevent irreparable damage to the vapor-cooled Shim Leads:

- Orifice on the Shim Lead Nupro Vent Valve is in place.
- Shim Lead is frosting and venting.
- Shim Power Supply current controls are set to zero (fully CCW).

NOTICE

The “Recommended Total Current” values found on the Acceptance Test Report (ATR) that shipped with the magnet must be entered into the Superconducting (S/C) Correction Coils before performing field mapping and any further S/C or passive shimming.

The coil groups are:

- Transverse 1 Coils: T1-1 to T1-6
- Transverse 2 Coils: T2-1 to T2-6
- Axial Coils: AX1 to AX6

Each coil group is connected to one heater circuit on the shim power supply. If the only current change was in the Axial 2 Coil, turning the Axial Switch Heater on would dump the currents in Axial Coils (AX1 to AX6) and the appropriate currents for each Axial Coil would need entering.

NOTE: Always check the ATR for any possible magnet-specific current settings.

1. Make sure vapor is escaping from the Shim Lead and the lead is frosted, then turn on the power supply.

NOTICE

Do not move articles or equipment in the Magnet Room while adjusting shim currents.

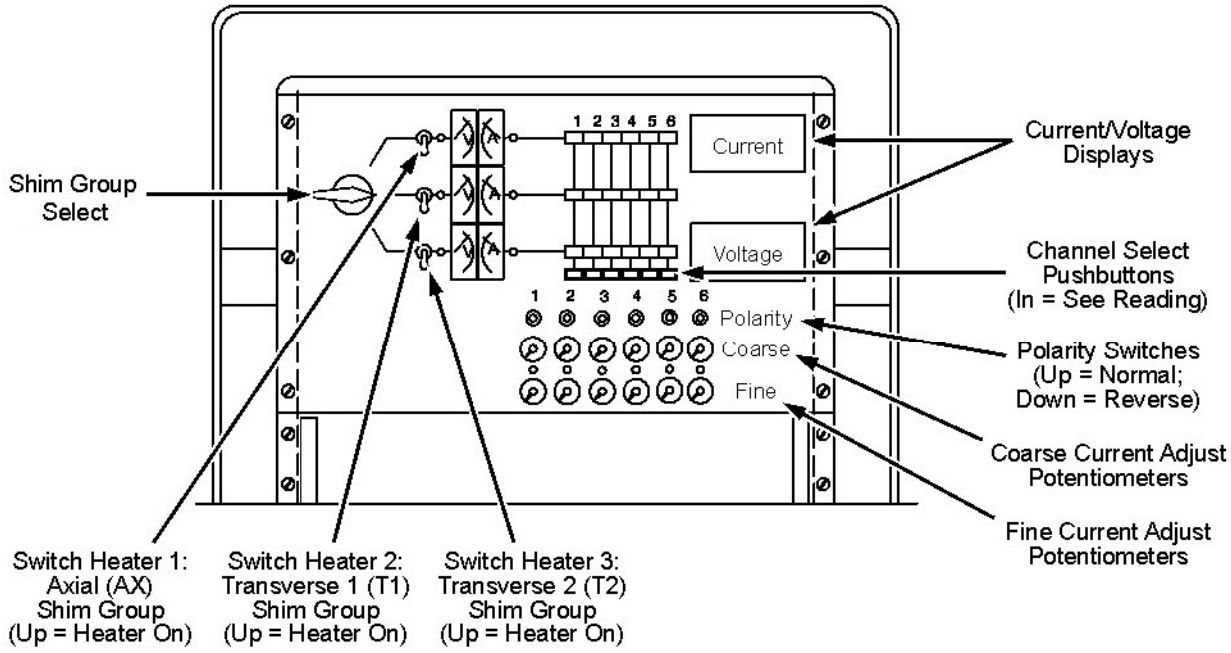
2. Repeat the following steps (Step 2.a through Step 2.g) to input ATR shim currents for each shim group in sequence: T1, then T2 and Axial. (See Table 3-11.)

    a. Set the Shim Group Select Switch to the appropriate group: T1, T2 or Axial. (See Illustration 3-104.)

Table 3-11: S/C Shim Groups

	Transverse 1 Shim Group	Transverse 2 Shim Group	Axial Shim Group
Course/Fine Adjust Potentiometer & Polarity Light/Switch	"Shim Group Select" Switch Setting		
	Middle	Bottom	Top
	Coil (Circuit)	Coil (Circuit)	Coil (Circuit)
1	T1-1 ($Z X^2Y^2$)	T2-1 (ZXY)	AX1 (Z^1)
2	T1-2 (X)	T2-2 (Y)	AX2 (Z^2)
3	T1-3 (Z^2X)	T2-3 (Z^2Y)	AX3 (Z^3)
4	T1-4 (ZX)	T2-4 (ZY)	AX4 (Z^4)
5	T1-5 (X^2Y^2)	T2-5 (XY)	AX5* (Z^5)*
6	T1-6* (X^3)*	T2-6* (Y^3)*	AX6* (Z^6)*
* Not applicable to W0 Series LCC300 magnets.			

Illustration 3-104: Shim Power Supply Controls (Front Panel)



b. Set the Course/Fine Current Adjust potentiometers on the Shim Power Supply to zero (0) amps (fully CCW).

NOTE: The polarity relays will not change polarity if there is any current flowing through their respective channels. The current must be reduced to zero before the relays will change to the position indicated by the external switches on the power supply.

NOTICE

Magnet damage is possible if heater currents are not set correctly.

c. Turn on the selected group's Switch Heater (Transverse 1, Transverse 2 or Axial) and wait 30 seconds for the switches to go resistive.

d. Set the ATR “total” currents and polarities for the shim coil group.

NOTICE

Since the LCC300 magnet correction coils have a greater time constant (inductance : resistance ratio) than those of a 1.5T magnet, a longer settling time is required for the shim currents. It is important that the shim current settling time is in conformance with Table 3-12 to prevent subsequent current drift after settling.

e. Allow the shim current to settle for the time shown in Table 3-12.

Table 3-12: Shim Current Settling Times (Re-establishing ATR)

Shim Coil Group	Settling Time
T1	20 minutes
T2	
Axial*	45 minutes*
* Axial times represent minimum times. Axial coupling may require longer wait times to meet the magnetic field stabilization requirements stated in Step 3 below.	

NOTICE

Failure to accurately set the power supply currents and polarity can greatly increase the number of plotting iterations (i.e., time to shim the magnet).

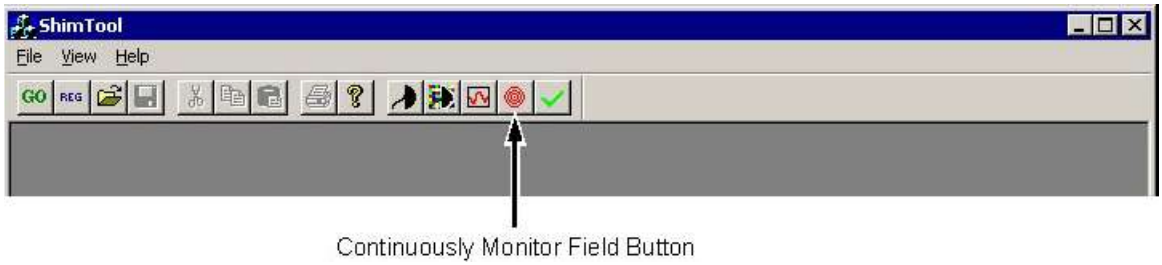
f. Verify the ATR currents, then turn off the heater group and wait five (5) minutes.

g. After waiting five minutes, gradually turn the power supply Current Adjust Potentiometers down to zero.

3. For axial currents **only**, monitor magnetic field drift until it stabilizes (i.e., <2 Hz change in total magnetic field strength over a two-minute period):

a. Click the [Continuously Monitor Field] button (second button from right) from ShimTool's main screen. (See the illustration below.)

Illustration 3-105: ShimTool Main Screen Buttons



b. Make sure the probe array is in the 30° position (slice/arc 2 in Table 3-13), then select **Probe 22.**

Table 3-13: Field Camera Mapping Slices (Positions)

Slice/Arc[a] (Position)	Degrees	Slice/Arc[a] (Position)	Degrees	Slice/Arc[a] (Position)	Degrees	Slice/Arc[a] (Position)	Degrees
0	0/360[b]	6	90[b]	12	180[b]	18	270[b]
1	15	7	105	13	195	19	285
2	30	8	120	14	210	20	300
3	45	9	135	15	225	21	315
4	60	10	150	16	240	22	330
5	75	11	165	17	255	23	345

Slice/Arc[a] (Position)	Degrees	Slice/Arc[a] (Position)	Degrees	Slice/Arc[a] (Position)	Degrees	Slice/Arc[a] (Position)	Degrees
[a] The slice/arc number shown here and in ShimTool corresponds with the number stamped on the mapping fixture's Positioning Wheel. [b] The remote box flashes slower at these positions.							

c. Select [Start] on the screen that displays to begin measuring field strength and drift. Record the starting frequency for use in Step 3.d.

d. Wait two (2) minutes, select [Stop], and record the change between the starting and present frequencies.

- If the change is <2 Hz, continue with Step 4.
- If the change is ≥2 Hz, repeat Step 3.c and Step 3.d.

4. Once the magnetic field is stable and the Axial settling time stated in Table 3-12 has elapsed, turn the Axial Switch Heater off, and allow the Heater to cool for five (5) minutes.

5. Slowly turn all the Course/Fine Current Adjust Potentiometers on the shim power supply back down to zero (0) amps (fully CCW).

6. Close the Shim Lead's Nupro Vent Valve.

7. Continue with Section 8.4.3, Running ShimTool.

8.4.3 Running ShimTool

8.4.3.1 Field Map Acquisition

NOTICE

The magnet's center frequency must be stable in conformance with the Section 8.4.1.3, Field Stability Check, before any alteration to the magnet's S/C or passive shims are made.

NOTICE

Moving articles or equipment in the Magnet Room may affect readings of magnetic field strength.

NOTE: Locate the Mapping Fixture and Shim Camera at the magnet's approximate center in conformance with Preparations for Field Measurement before centering the Probe Array using ShimTool.

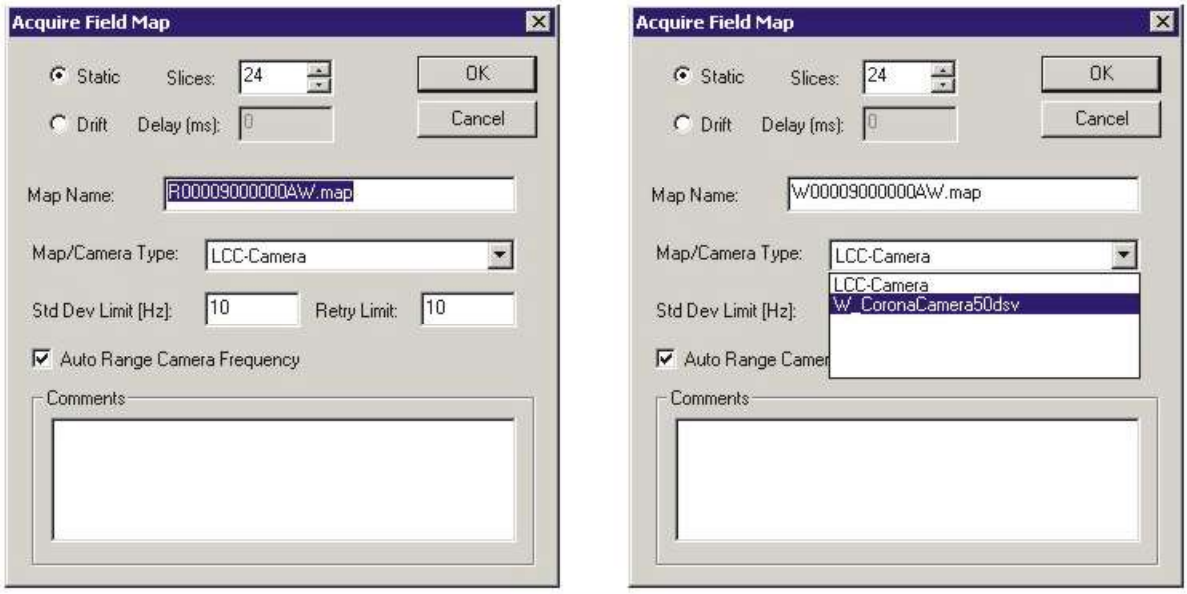
1. Click the [Acquire Field Map] button (fourth button from right) from ShimTool's main screen. (See below.)

Illustration 3-106: Acquire Field Map Button on ShimTool Main Screen

2. Click the [Static] button when the screen shown in Illustration 3-107 displays, and then select **W_CoronaCamera50dsv** from the *Map/Camera Type* drop-down menu.

   NOTE: Leave the default number beside **`Slices:`** and the file name beside **`Map Name:`** unchanged.

Illustration 3-107: Acquire Field Map



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3. Make sure the curved part of the field camera's probe array faces directly up (0° position).

NOTICE

Moving any articles or equipment in or near the Magnet Room may affect the field map.

NOTICE

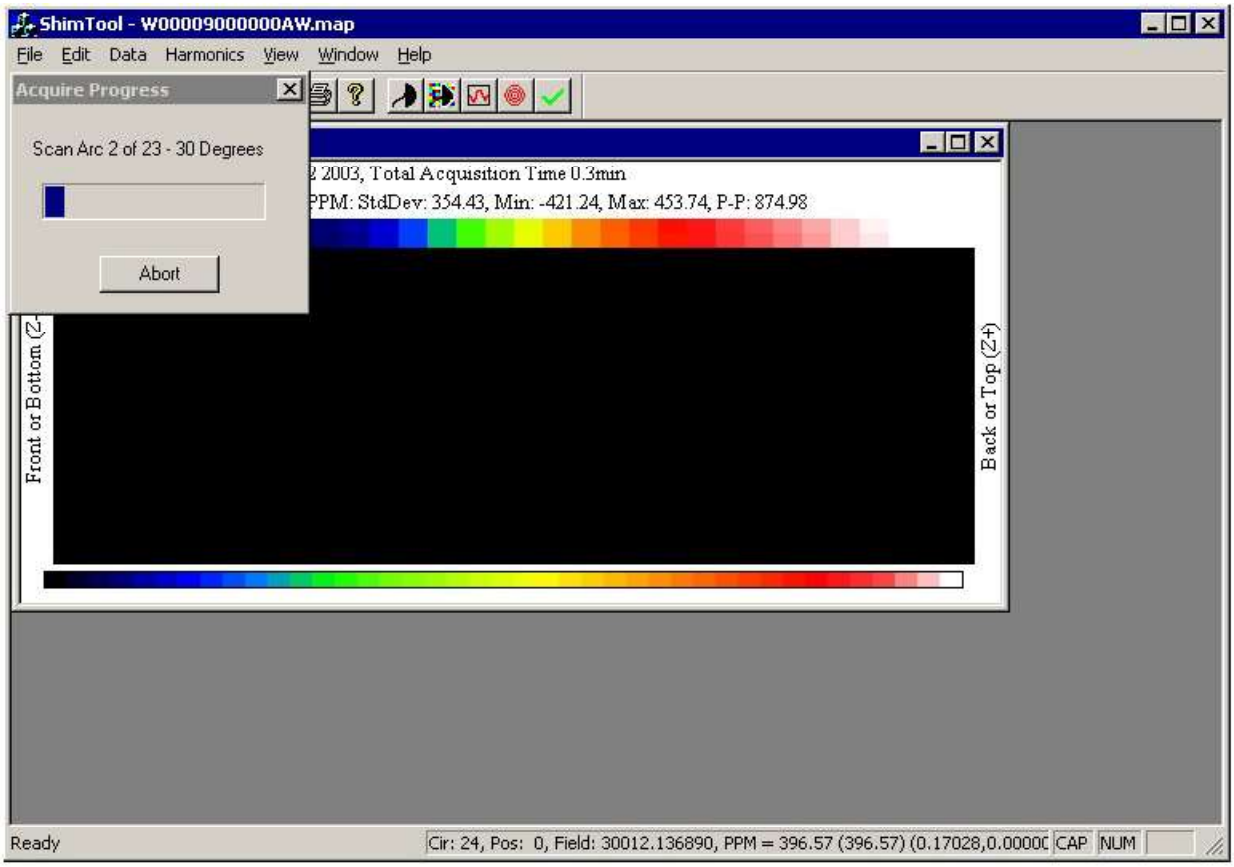
Do not allow nonessential conversation/distractions during map acquisition. If an error occurs during field map acquisition:

- **Click the [Abort] button in the *Acquire Progress* window (shown in Illustration 3-108), and press the field camera's remote box switch one more time.**
- **Retake the map starting at Step 1.**

4. Select [OK] to begin mapping the magnet's magnetic field.

NOTE: The field map screen will display with the *Acquire Progress* window overlaid. (See the illustration below.) The field camera's remote box should also start to flash repeatedly.

Illustration 3-108: Field Map Being Acquired



5. Press the field camera's remote box switch when it starts flashing repeatedly. The light will stop flashing and stay on while one slice of the field map will be acquired (except after the last slice when the light will go off).

6. When the camera's push-button switch starts flashing repeatedly again, slowly and smoothly rotate the camera one position (15°) clockwise.

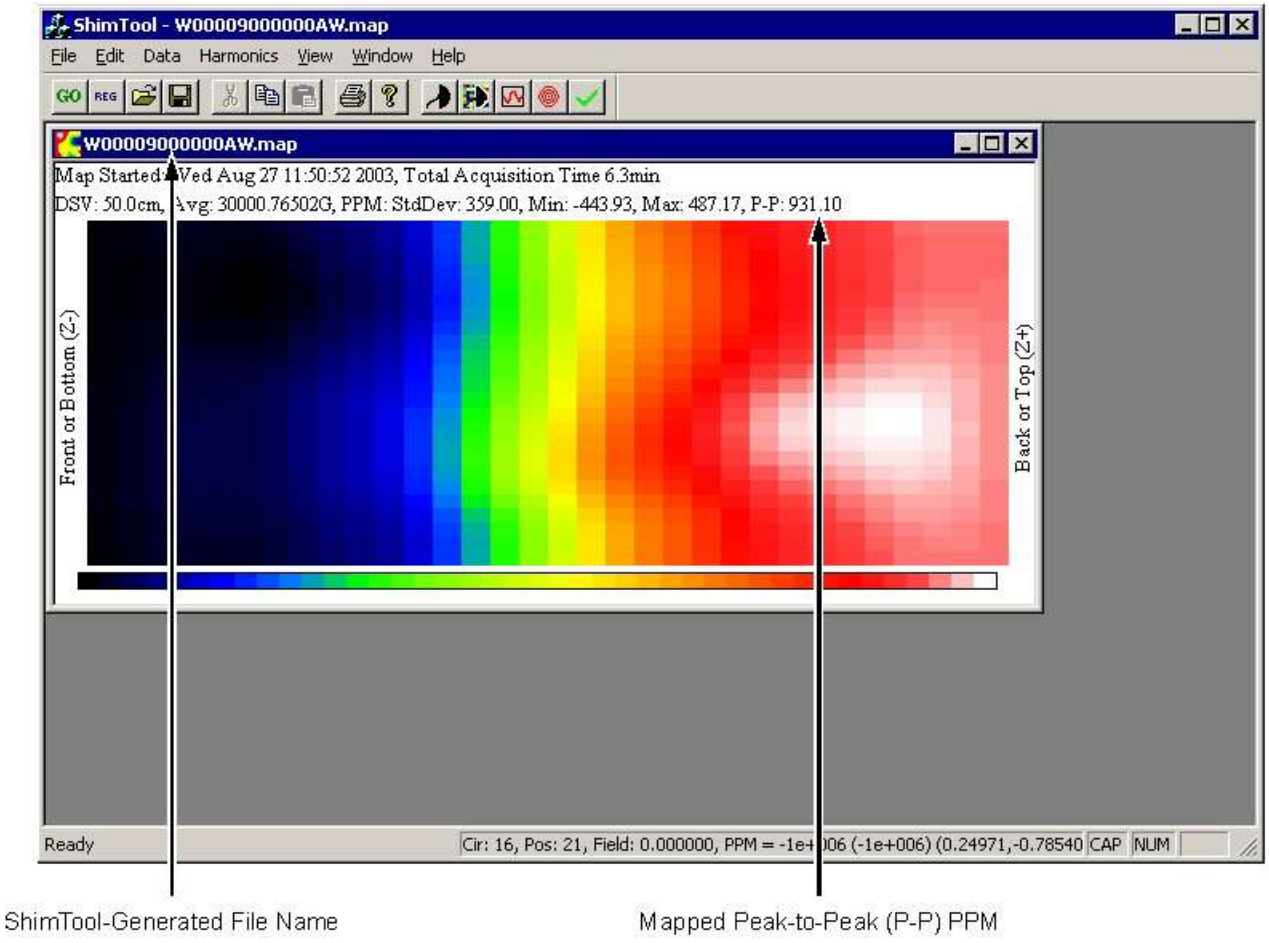
7. Repeat Step 5 and Step 6 until 24 map slices (slice 0 at 0°/360° through slice 23 at 345°) are taken. (See Table 3-13 for a summary of the slices.)

   NOTE: The remote box will flash slower at positions 0 (0°/360°), 6 (90°), 12 (180°) and 18 (270°).

   NOTE: When all 24 slices are taken, the finished map displays on the field map screen shown in Illustration 3-109. ShimTool automatically assigns a sequential alphabetic name to both the displayed map and the `.map` file it creates. The file name consists of:
   - The magnet series and number information entered on the *Register Magnet Type* screen shown in Illustration 3-100, Field Camera Set-Up Using ShimTool (W0 + 0009 becomes W00009; WB + 0002 becomes WB0002.)
   - A sequential alphabetic character (A, B, ... C becomes 0000A, 0000B, ... 0000C.)
   - The test cell entered on the *Register Magnet Type* screen shown in Illustration 3-100, Field Camera Set-Up Using ShimTool. Always use test cell "W" when shimming at a customer site.
   - Plus the `.map` file extension.

8. Record the mapped peak-to-peak (P-P) ppm figure displayed on the *Field Map* screen (shown below) in Chapter 8, Shimming Process Data on the same line as the map name.

Illustration 3-109: Sample First Field Map Screen for Axial Centering

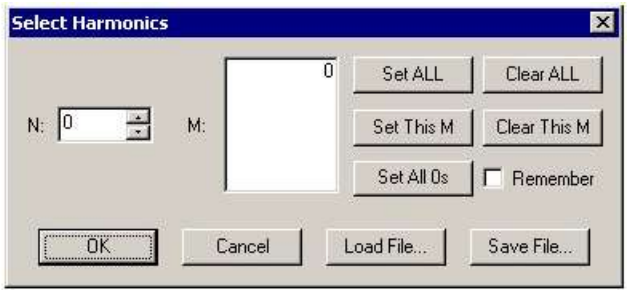


9. If this is the first field map taken since the mapping fixture was installed or moved in any substantial way, use this map to axially center the probe array:

   a. Choose **Decompose (F6)** from the *Harmonics* menu (fourth menu from the left in Illustration 3-109).

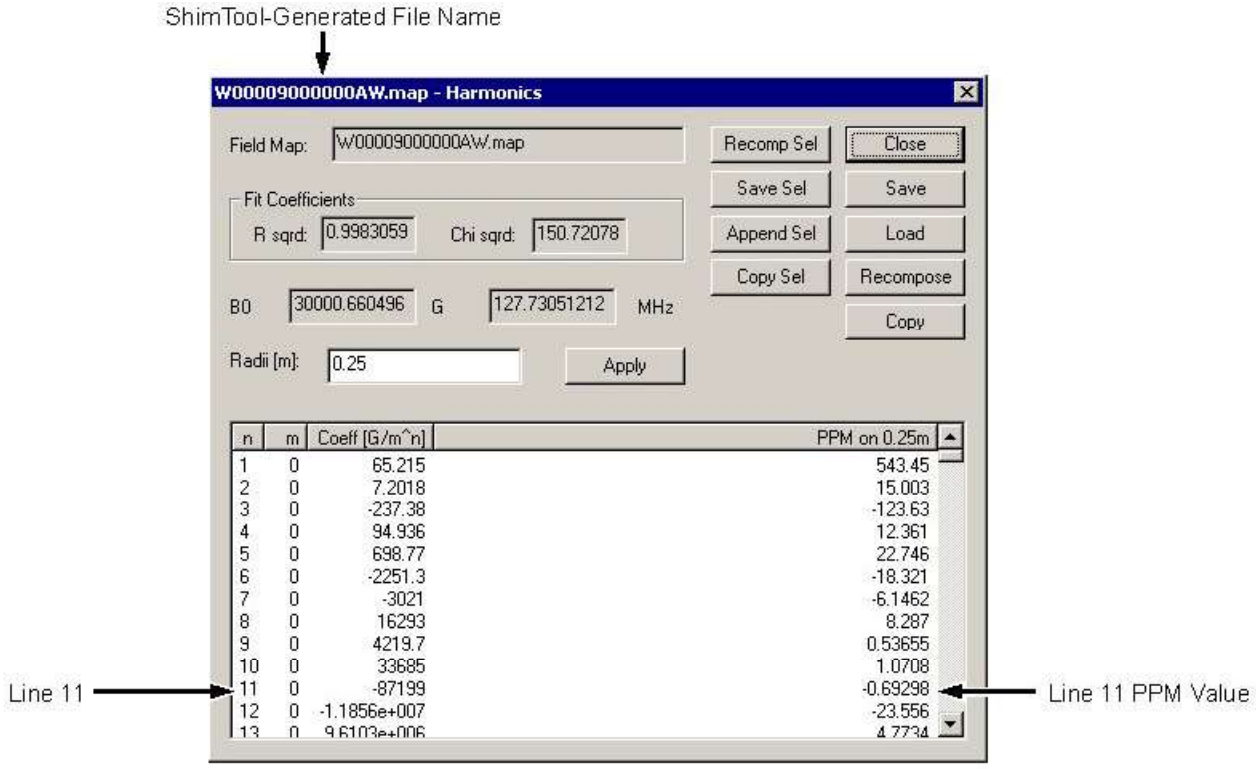
   b. Select [OK] when the screen shown below displays.

Illustration 3-110: Select Harmonics



   c. Examine the PPM value at the right end of Line 11 when the screen below displays.

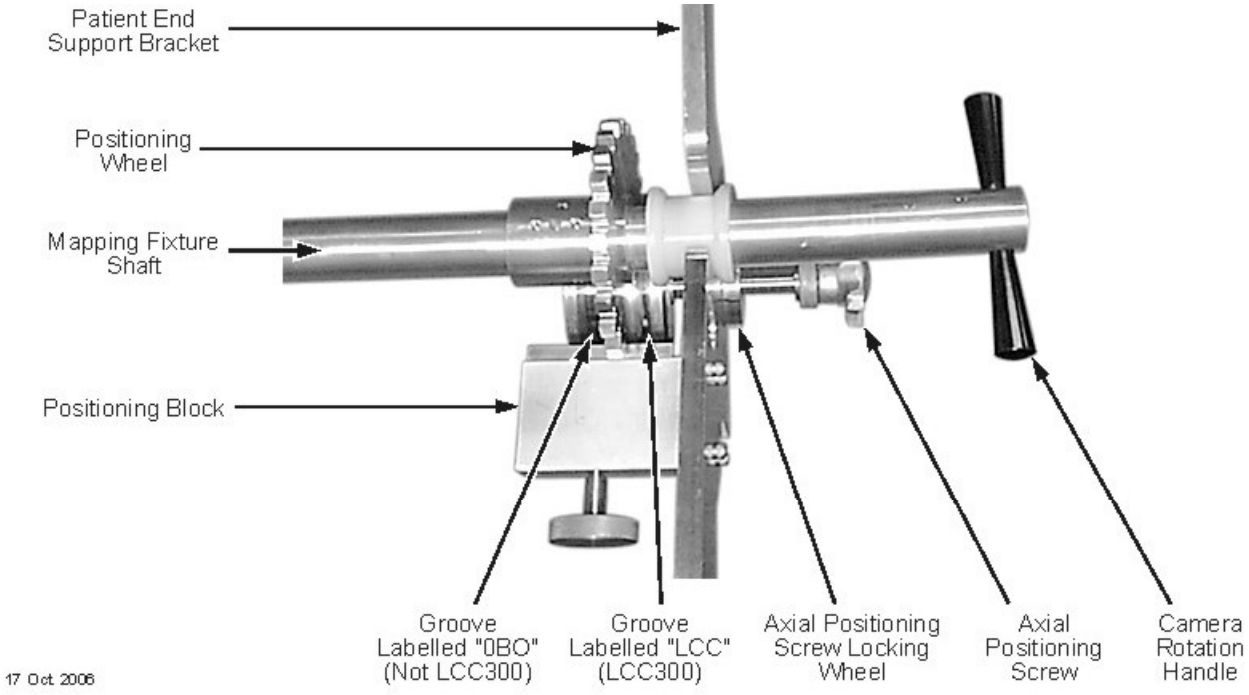
Illustration 3-111: Field Map Harmonics



d. If the PPM value on Line 11 (harmonic 11, 0) is >-1.0 ppm and <+1.0 ppm, the probe array is centered axially. Continue with Step 10, and use this centered map to run ShimTool set for S/C shimming.

e. Verify that the mapping fixture's Positioning Wheel is in the groove labelled **LCC.** (See the illustration below.)

Illustration 3-112: Mapping Fixture 2380758's Axial Positioning Screw



f. Divide this PPM value by 1.7 as shown below.

$$\frac{\text{PPM Value on Line 11}}{1.7} = \text{Number of Turns of Mapping Fixture's Axial Positioning Screw Required to Axially Center Probe Array}$$

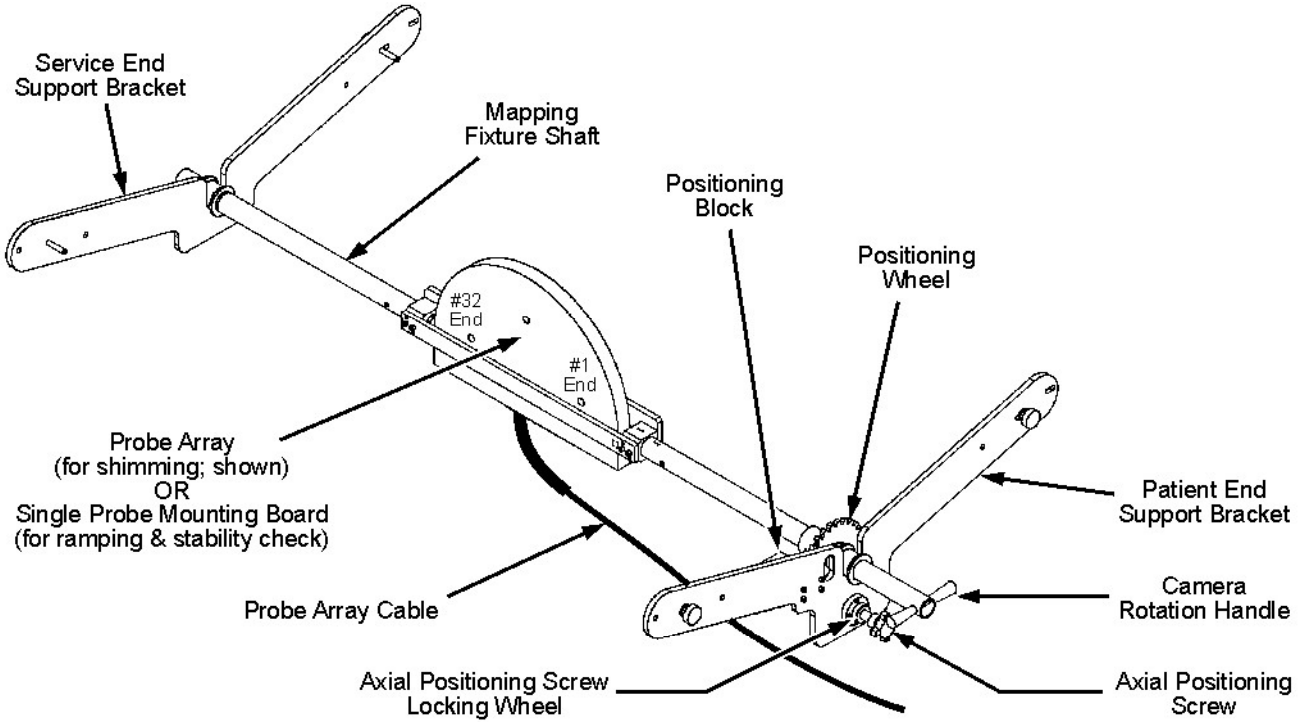
NOTE: On normal polarity magnets:

- Positive (+) PPM value: Turn clockwise (CW).
- Negative (-) PPM value: Turn counterclockwise (CCW).

NOTE: Turning in increments smaller than a quarter turn is not necessary.

g. Loosen the axial positioning screw locking wheel, carefully turn the axial positioning screw (shown in Illustration 3-112 and Illustration 3-113) the number of full turns calculated in Step 9.f, and tighten the locking wheel.

Illustration 3-113: LCC300 Field Mapping Fixture 2380758 Basic Components



h. Record the ShimTool-generated **`.map`** file name in Chapter 8, Shimming Process Data in the upper section: *Maps for Probe Centering*.

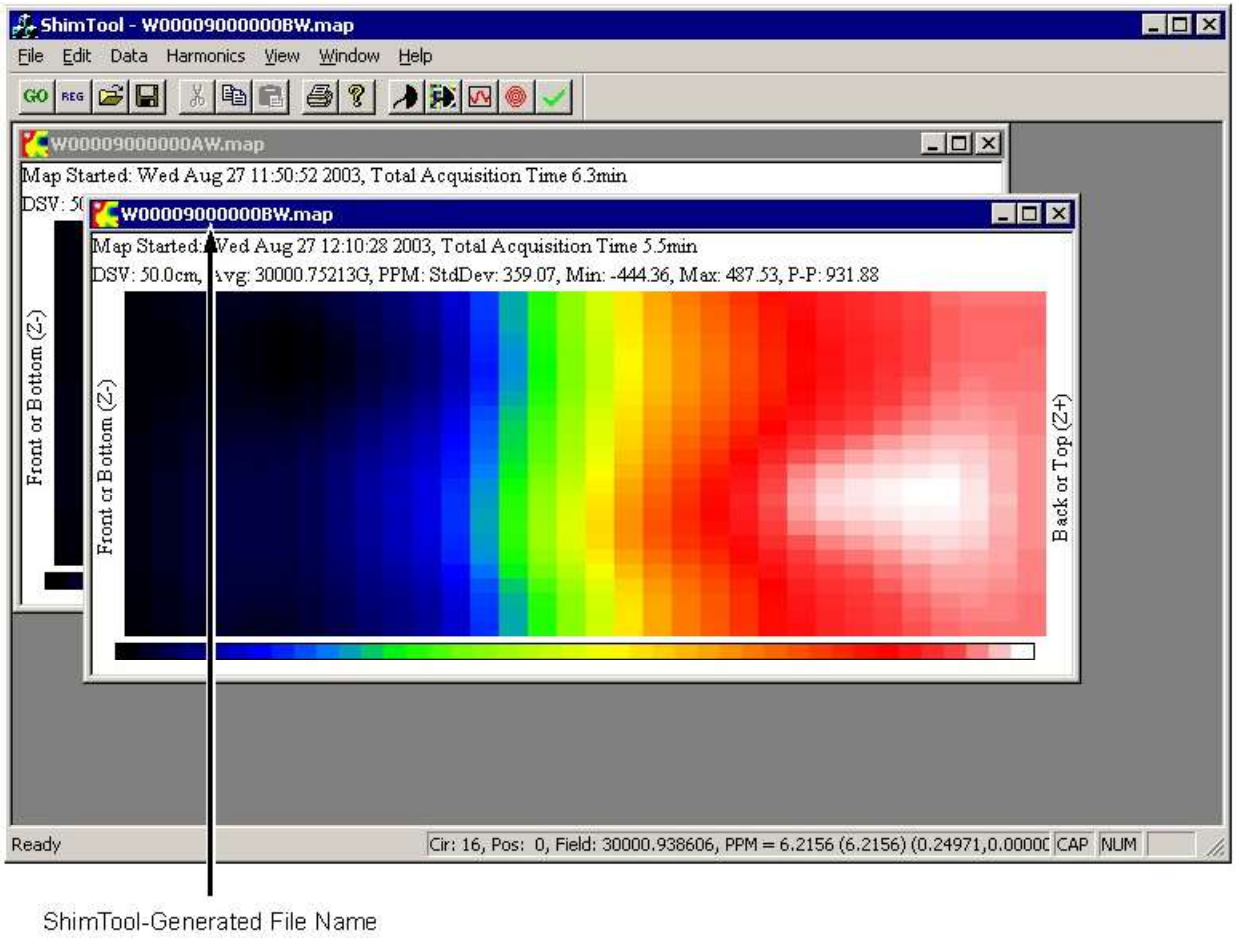
i. Repeat Step 1 through Step 7 and Step 9.a through Step 9.d to verify axial centering of the probe array.

10. Record the ShimTool-generated **`.map`** file name in the appropriate place(s):

- Record map names used for hybrid shimming (passive and superconducting) in Chapter 8, Shimming Process Data, Chapter 8, Passive Shimming Data, and Chapter 8, SC Shimming Data.
- Record map names used when running ShimTool for superconducting only in Chapter 8, Shimming Process Data and Chapter 8, SC Shimming Data.

11. Close ShimTool's harmonics window(s).

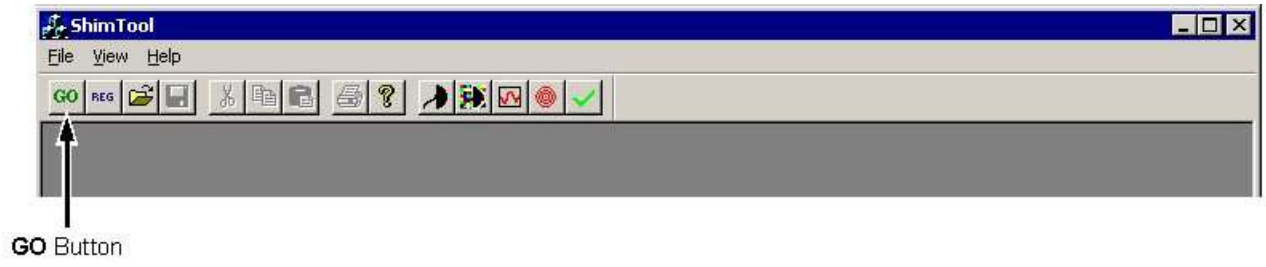
Illustration 3-114: Sample Field Map Screen for Shimming



8.4.3.2 Acquiring a Shim File

1. Click the [GO] button (first button on left) from ShimTool's main screen. (See the illustration below.)

Illustration 3-115: ShimTool Main Screen Buttons



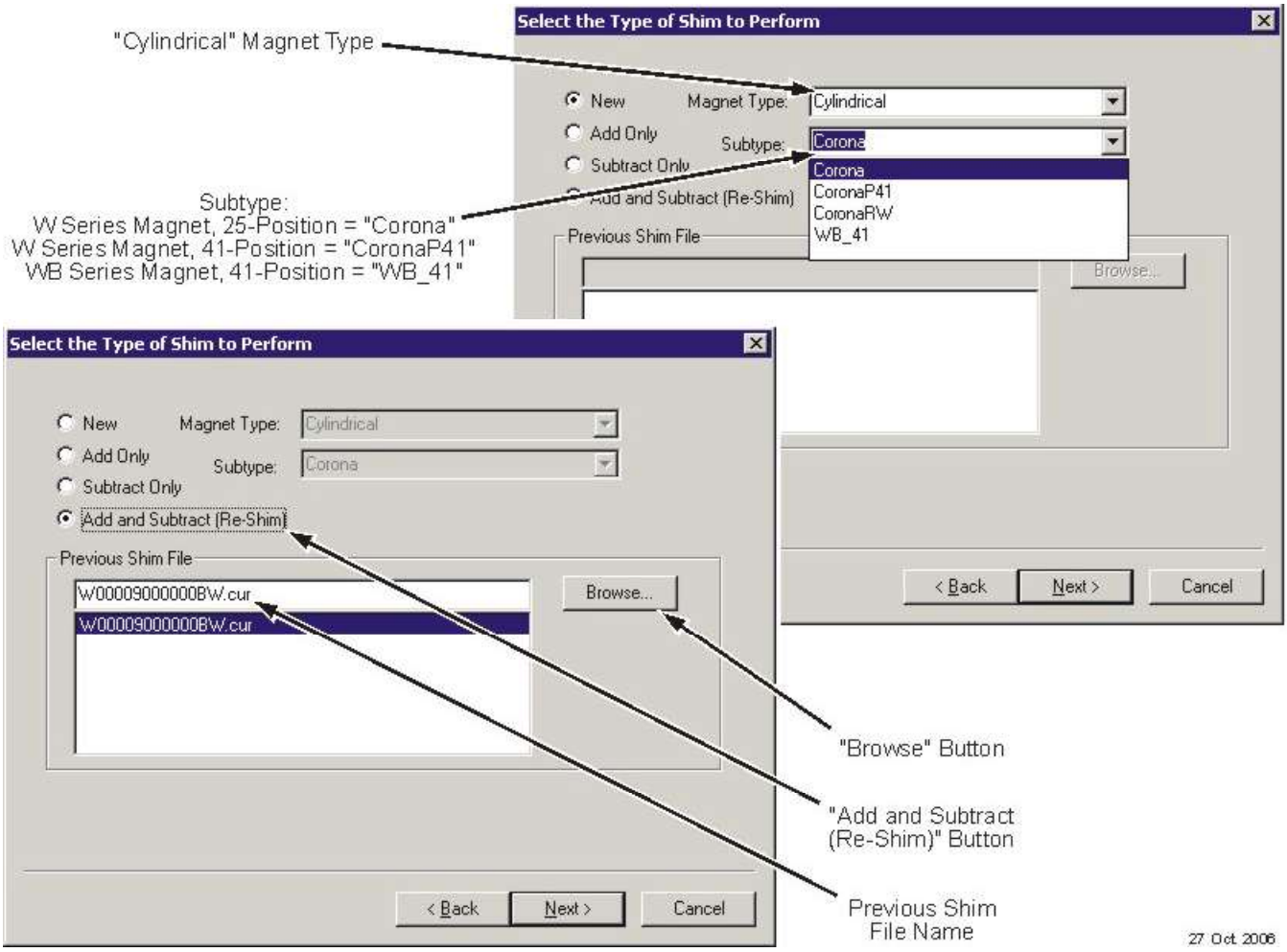
2. Select the [Shim or Reshim a Magnet] radio button and [GO] when the following screen displays.

Illustration 3-116: What Would You Like to Do? Screen

3. When the *Select the Type of Shim to Perform* screen shown in Illustration 3-117 displays:

   a. Verify that the *Magnet Type* field reads **Cylindrical**.

Illustration 3-117: Select the Type of Shim to Perform Screen



   b. Select the correct Magnet Subtype stated in Table 3-14.

Table 3-14: Magnet Subtype and Calibration File Choices

Series	Positions	Correct Choices		
		Magnet Subtype	Passive Calibration File	Active Calibration File
W	25[a]	Corona	W_CoronaP.cal	W_CoronaSC.cal
W	41[a]	CoronaP41	W_CoronaP41.cal	W_CoronaSC.cal
WA	41	CoronaRW	W_CoronaP41.cal	W_CoronaSC_MarkII
WB	41	G3_41	W_CoronaP41.cal	WB_CoronaSC_MarkIII

[a]W Series LCC300 magnets with serial numbers W00006, W00029, W00044 (on site), W00058, W00069 and ≥ W00100 use 41-position passive shimming. All WB Series LCC300 magnets are shimmed using 41 positions.

c. Click the [Add and Subtract (Re-Shim)] button.

NOTE: Verify the information in the *Magnet Type* and *Subtype* fields before selecting [Add and Subtract (Re-Shim)] since these fields cannot be changed after this button is selected.
ShimTool is only run with the [New] button selected at the factory.

NOTICE

Do not use incorrect file names.
Keep track of file names and iterations used and what they were used for by entering this information in Chapter 8, Shimming Process Data (master log of the shimming process) and the Data Sheets affected by superconductive shimming (Chapter 8, SC Shimming Data) and by hybrid shimming (Chapter 8, Passive Shimming Data and Chapter 8, SC Shimming Data) so that accurate file names can be used at any later time.

NOTICE

Use the ATR `.cur/.shm` file names as "Previous Shim File" for the first iteration of ShimTool after the ATR S/C currents are reestablished. Make sure these files are copied to the computer's subdirectory for the magnet (created in Section 8.4.1.5, Step 3.b) before starting the iteration.

4. Accurately select the Previous Shim File name (the last file with the `.cur` extension for S/C shimming or `.shm` extension for passive shimming) from the list beside **`Previous Shim File:`**.

NOTE: If the output file is not located as stated in Table 3-15 and the full path to the correct shim file cannot be recalled, click the [Browse] button, locate the correct file, select it, and open the file.

Table 3-15: Directory Path, File Names & File Format

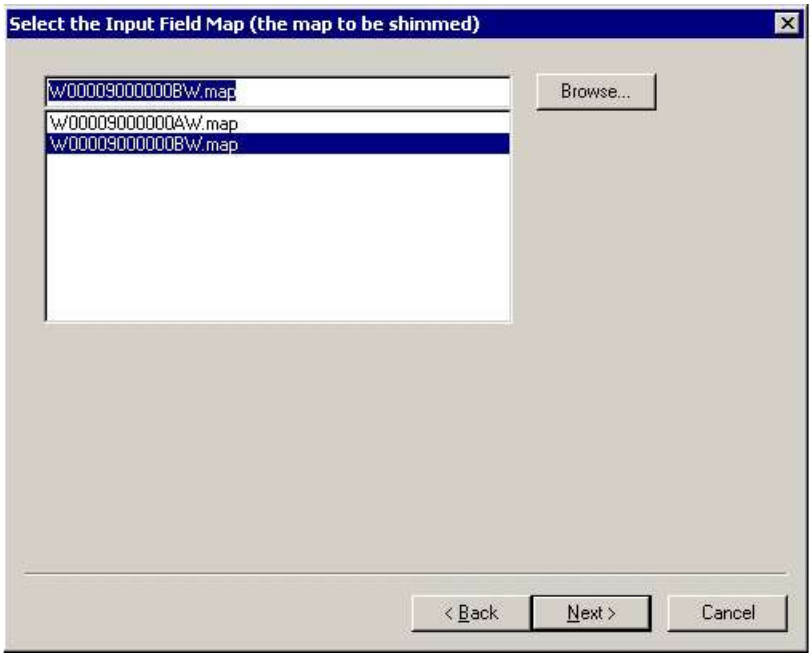
Magnet	Series	File Type	Directory Path to File	
			Windows 2000	Windows XP
3.0T LCC300	W	SC	C:\MRshim\W0####0\W0####0.cur	D:\MRshim\W0####0\W0####0.cur
		Passive	C:\MRshim\W0####0\W0####0.shm	D:\MRshim\W0####0\W0####0.shm
		Map	C:\MRshim\W0####0\W0####0.map	D:\MRshim\W0####0\W0####0.map
	WA	SC	C:\MRshim\WA####0\WA####0.cur	D:\MRshim\WA####0\WA####0.cur
		Passive	C:\MRshim\WA####0\WA####0.shm	D:\MRshim\WA####0\WA####0.shm
		Map	C:\MRshim\WA####0\WA####0.map	D:\MRshim\WA####0\WA####0.map
	WB	SC	C:\MRshim\WB####0\WB####0.cur	D:\MRshim\WB####0\WB####0.cur
		Passive	C:\MRshim\WB####0\WB####0.shm	D:\MRshim\WB####0\WB####0.shm
		Map	C:\MRshim\WB####0\WB####0.map	D:\MRshim\WB####0\WB####0.map
Directory path format: Drive letter + `:\MRshim\` + seven (maximum) character Subdirectory Name + `\` + File Name. Seven-character Subdirectory Name format: Series Number (box beside `Series:` + `0` (if required) + Magnet Number (box beside `Number:`) + Helium Vessel Number (assigned at the factory).				

5. Verify all information on the *Select the Type of Shim to Perform* screen is accurate, then select [Next>].

6. When the *Select the Input Field Map* screen shown in Illustration 3-118 displays, accurately type the file name of the last field map (`.map` extension) taken in Section 8.4.3.1, Field Map Acquisition.

   NOTE: If the output file is not located as stated in Table 3-15 and the full path to the correct map file cannot be recalled, click the [Browse] button, locate the correct file , select it, and open the file.

Illustration 3-118: Select the Input Field Map Screen

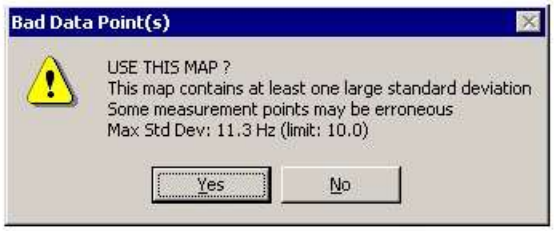


7. Select [Next>].

NOTE: ShimTool will look at the data contained in the file specified in Step 6.

- If the map file specified contains bad data, the alert shown in Illustration 3-119 displays. (If the specified map file is good, this illustration will not display.)
- Select [No] and retake the map in conformance with Section 8.4.3.1, Field Map Acquisition, making sure all connections are good and that the cable is not wrapping around the mapping fixture.

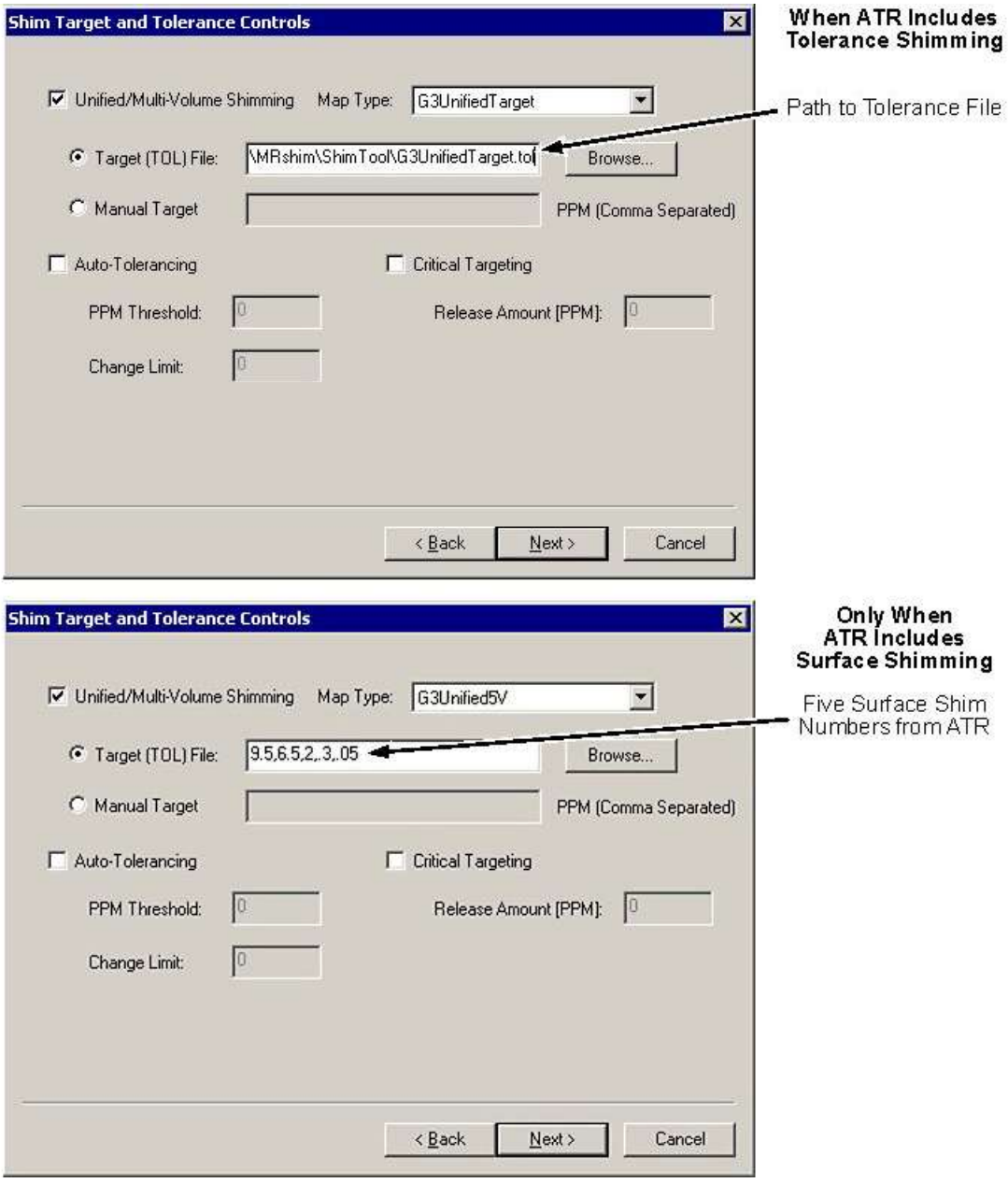
Illustration 3-119: Bad Data Point(s) Alert



8. Select **`Unified/Multi-Volume Shimming`** when the *Shim Target and Tolerance Controls* screen (shown in Illustration 3-120) displays.

   a. Make sure the *Map Type* field reads **`G3UnifiedTarget`**.

Illustration 3-120: Shim Target and Tolerance Controls



b. Select [Target (TOL) File] radio button.

- If the ATR was produced using Tolerance Shimming, the path to **`G3UnifiedTarget.tol`** displays in the field to the right of **`Target (TOL) File:`**.

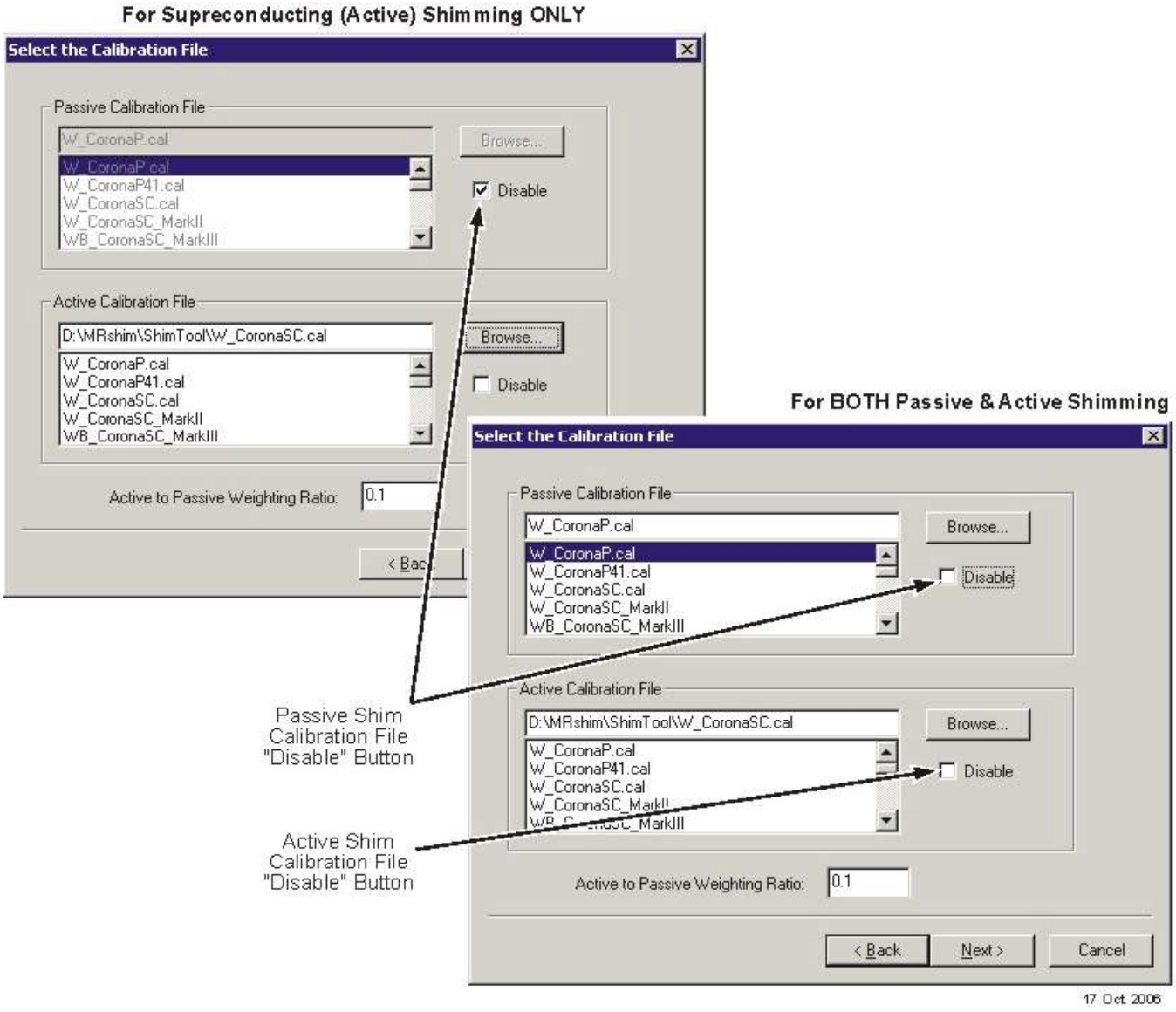
NOTE: The Windows XP path to the tolerance file should be: **`D:\MRshim\ShimTool\G3UnifiedTarget.tol`**. Windows 2000 installations use the **`C:`** drive instead of the **`D:`** drive. If the correct tolerance file is not located there and the full path to the correct location cannot be recalled, click the [Browse] button, locate the correct file, select it, and open the file.

- If the ATR was produced using Surface Shimming, a string of five numbers separated by commas displays in the field to the right of **`Target (TOL) File:`**.

  NOTE: The choice between Tolerance and Surface Shimming is made at the factory to give the best shimming results. This choice only affects the screen shown in Illustration 3-120, the ShimTool text file shown in Illustration 3-127 and Illustration 3-128 and the quantity of shims used, but has **no** procedural impact on the Field Engineer.

9. Click [Next>] to proceed to the *Select the Calibration File* screen shown below.

Illustration 3-121: Select the Calibration File Screen



10. Select the **`.cal`** file from the scrolling list of available calibration file list below **`Passive Calibration File`** (shown in Illustration 3-121) to match the number of shim positions stated in the ATR. Table 3-14 shows the correct selection choices.

    NOTE: LCC300 magnets with serial numbers W00006, W00029, W00044 (on site), W00058, W00069 and ≥W00100 use 41-position passive shimming. All WB Series LCC300 magnets are shimmed using 41 positions.
    Shim tray positions are shown Section 8.4.4, Passive Shimming.

11. For W Series LCC300 magnets, select **`W_CoronaSC.cal`** from the scrolling list of available calibration files listed below **`Active Calibration File`**. For WB Series LCC300 magnets, select **`WB_CoronaSC_MarkIII`**. (See Illustration 3-121 and Table 3-14.)

NOTE: If either the active or passive calibration files do not display in the respective scrolling lists, click the [Browse] button, locate the correct file, select it, and open the file. The Windows XP paths to the calibrations files should be **`D:\MRshim\Shimtool\*.cal`** (where the * represents the correct calibration file as stated in Table 3-14). Windows 2000 installations use the **`C:`** drive instead of the **`D:`** drive.

12. If only one type of shimming (passive or active) will be done during this iteration (shown in Illustration 3-96, Shimming Flowchart), select the [Disable] box (shown in Illustration 3-121) as follows:

    - Select the [Disable] box beside **`Passive Shim Calibration File`** if preparing to **only** perform superconducting (active) shimming (Section 8.4.5, Superconducting Shimming).
    - Select the [Disable] box beside **`Active Shim Calibration File`** if preparing to **only** perform passive shimming (Section 8.4.4, Passive Shimming). **(Not recommended.)**

      NOTE: Normally, the Active Shim Calibration File is never disabled.

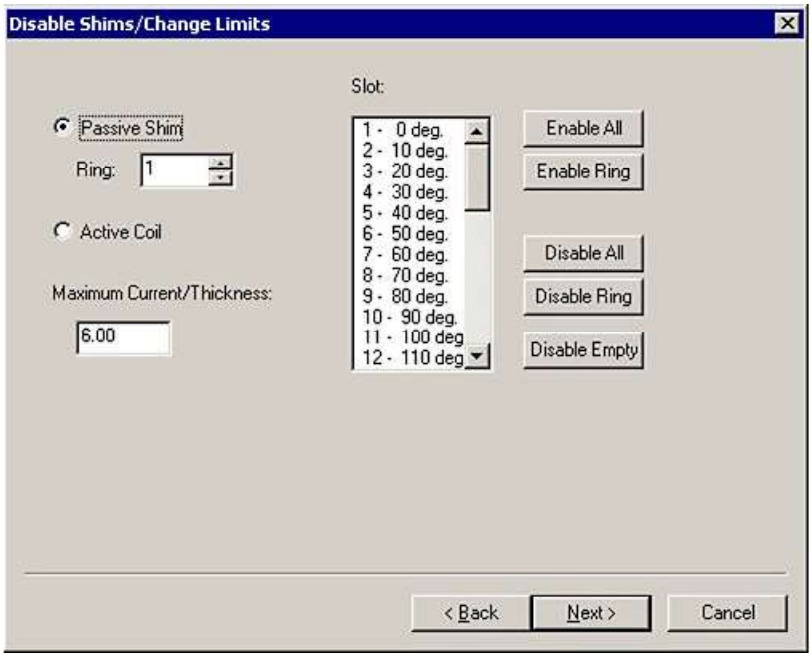
NOTICE

ShimTool will allocate the results of its calculations to all forms of shimming that are not disabled. Extra shimming iterations may result from not setting the disable boxes accurately for the type of shimming being done.

13. Click [Next>].

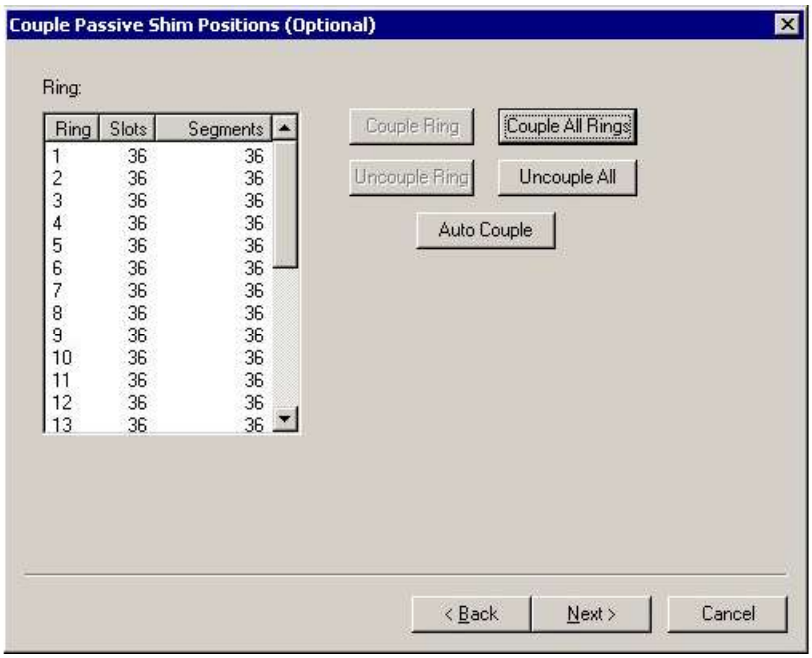
14. Click [Next>] without making changes to the *Disable Shims/Change Limits* screen (shown below) when it displays.

Illustration 3-122: Disable Shims/Change Limits Screen



15. Click [Next>] without making changes to the *Couple Passive Shim Positions (Optional)* screen (shown below) when it displays.

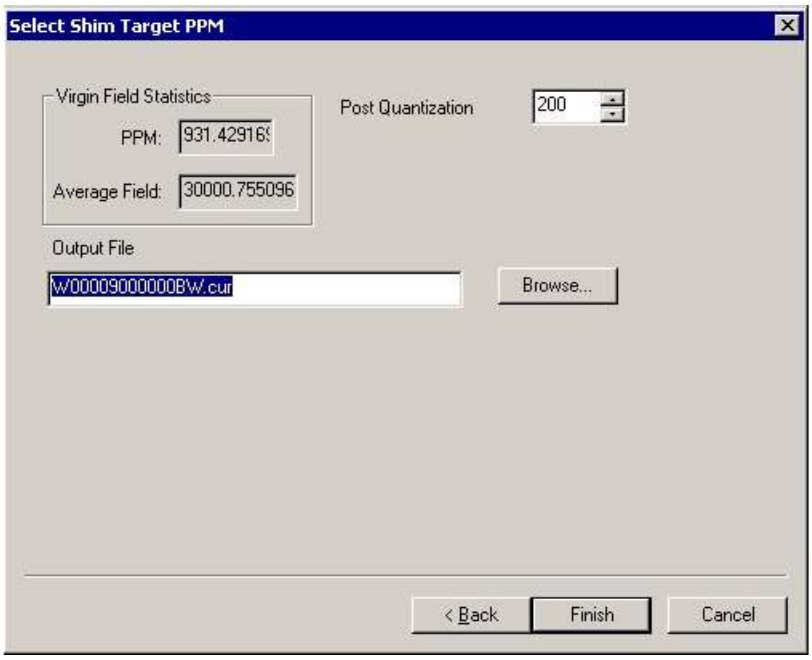
Illustration 3-123: Couple Passive Shim Positions (Optional) Screen



16. Verify that the output file name on the *Select Shim Target PPM* screen (Illustration 3-124) that displays next, matches the **`.map`** file name, but with a **`.shm`** or **`.cur`** extension. Make no other changes to the this screen.

NOTE: If the output file is not located as stated in Table 3-15 and the full path to the correct map file cannot be recalled, click the [Browse] button, locate the correct **`.map`** file, select it, and open the file. Once opened, change the file extension to **`.shm`** for passive shimming output or to **`.cur`** for S/C shimming output.

Illustration 3-124: Select Shim Target PPM Screen



17. Use the [<Back] button as required to review and verify all entries and choices on previous screens are correct.

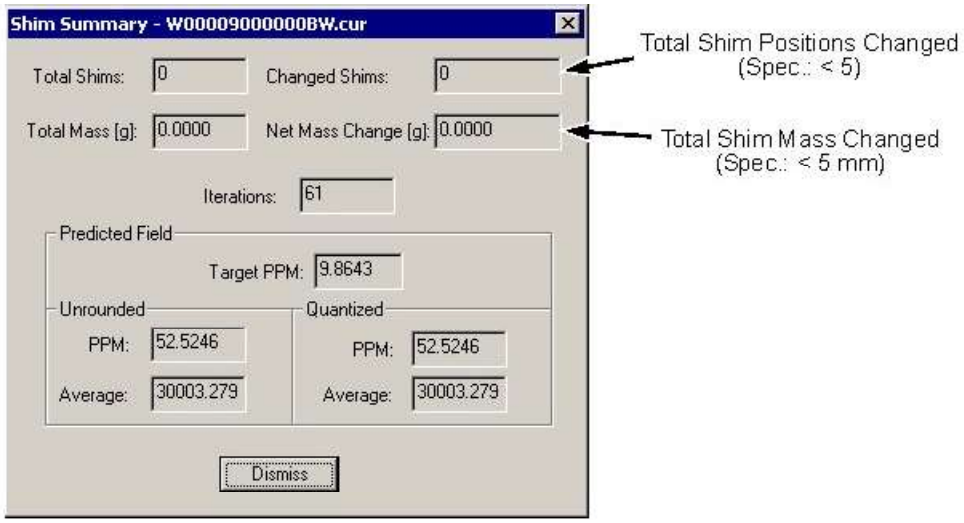
18. Click [Finish]. ShimTool will begin processing the shimming information.

NOTE: A *Shim Status* window will display while ShimTool is processing and close when the processing is complete.

8.4.3.3 After ShimTool Processing

1. Click [Dismiss] when the *Shim Summary* screen (similar to the following illustration) displays.

Illustration 3-125: Shim Summary Screen



2. When the more complete shim iteration results display (similar to those shown in Illustration 3-126), print the ShimTool results:

   - The **`.cur / .shm`** text file is automatically saved by ShimTool. It can be printed from NotePad, WordPad or a word processor for pages similar to Illustration 3-127 and Illustration 3-128. ShimTool can also open previously saved files for on-screen viewing by selecting **Show the output SHM file** from the *Shim* menu.
   - To obtain a multi-page paper version of the ShimTool results similar to Illustration 3-129 through Illustration 3-133:
     1. Choose **Print Lists...** from the *File* menu,
     2. Set the page orientation to **Landscape**, and
     3. Click the [OK] button. (The multi-page paper version is generally easier to use while placing shims in the shim trays.)

   NOTE: The "Passive Shims - Incremental Rounded Shim" information on Page 3 of ShimTool's printout (Illustration 3-131 and Illustration 3-132) is the same information as contained under "Incremental - Quantized" in the **`.shm`** file (Illustration 3-128). This page now shows the amount of change and the resulting total at each shim position to be changed. (**`.cur`** files do not contain incremental information.)
   The "Passive Shims - Total Rounded Shim" information on Page 4 of ShimTool's printout (Illustration 3-131 and Illustration 3-133) is the same information as contained under "Total - Quantized" in the **`.shm`** file (Illustration 3-128).

   NOTE: The following illustrations show the **`C:`** drive directory paths used by Windows 2000 ShimTool installations. Windows XP installations use **`D:`** drive directory paths instead.

Illustration 3-126: Shim Iteration Results Displays

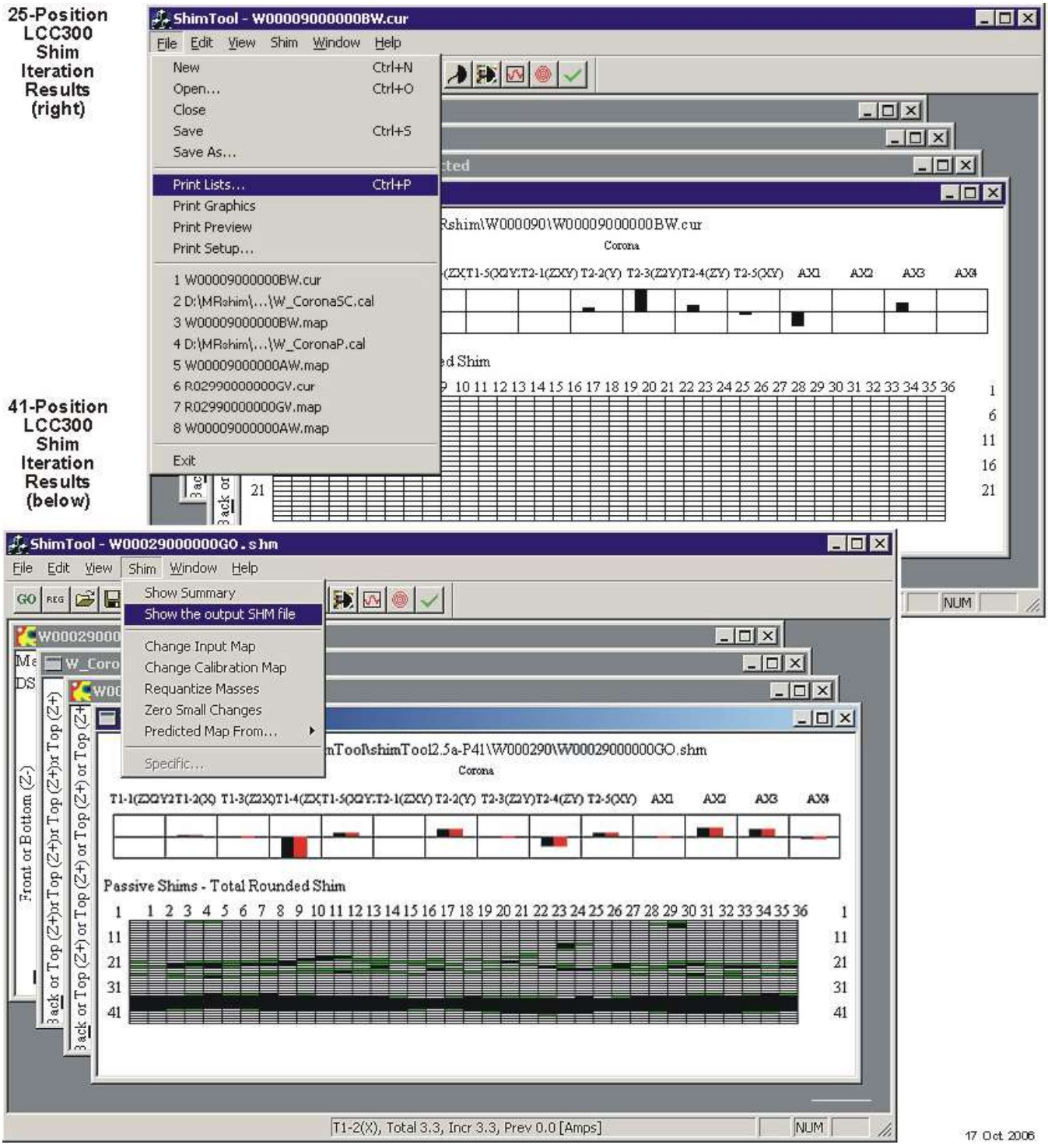


Illustration 3-127: Sample ShimTool Text File Displays (1 of 2)

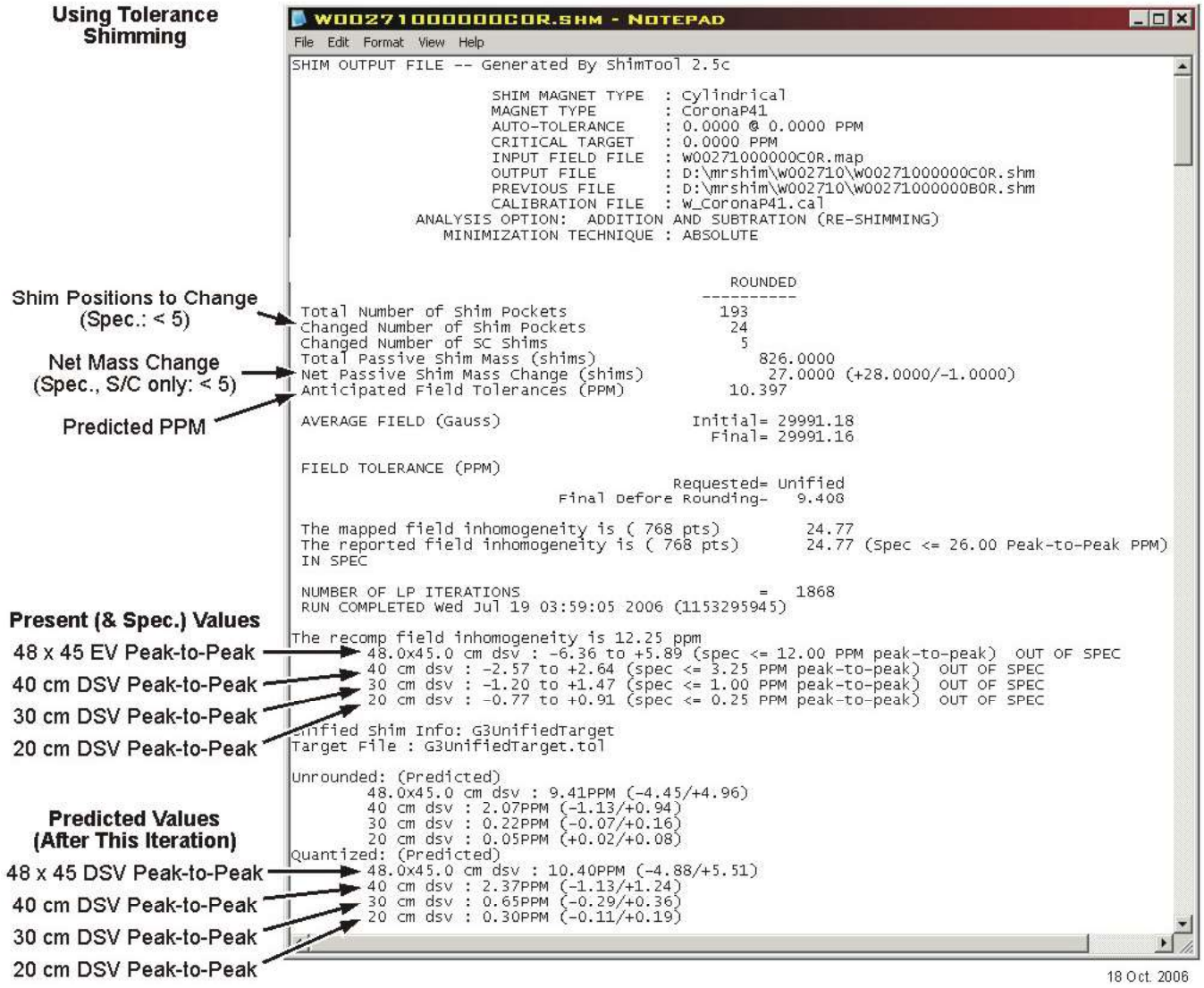


Illustration 3-128: Sample ShimTool Text File Displays (2 of 2)

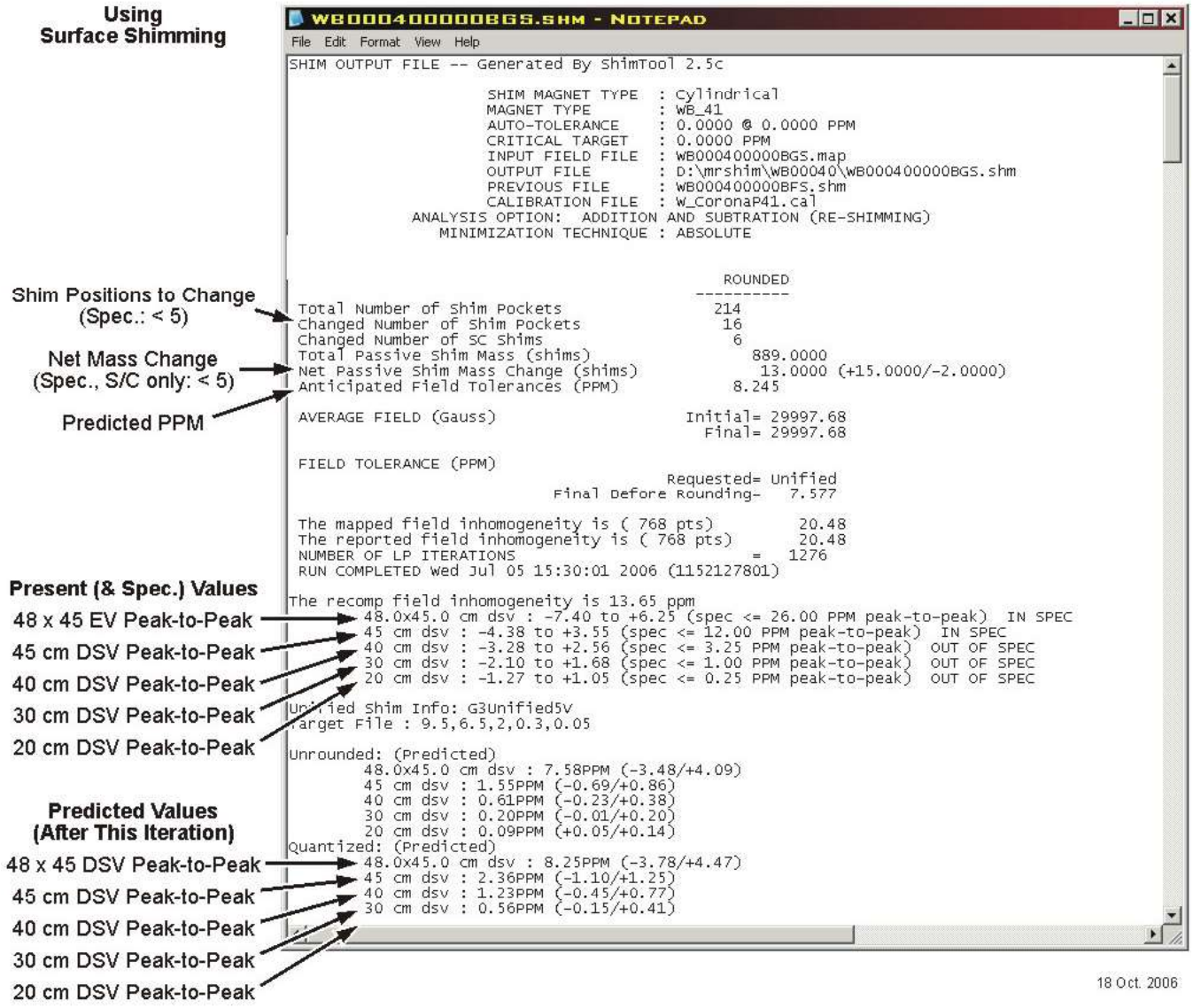


Illustration 3-129: Example ShimTool Printed Report, W Series LCC300, Pages 1 and 2

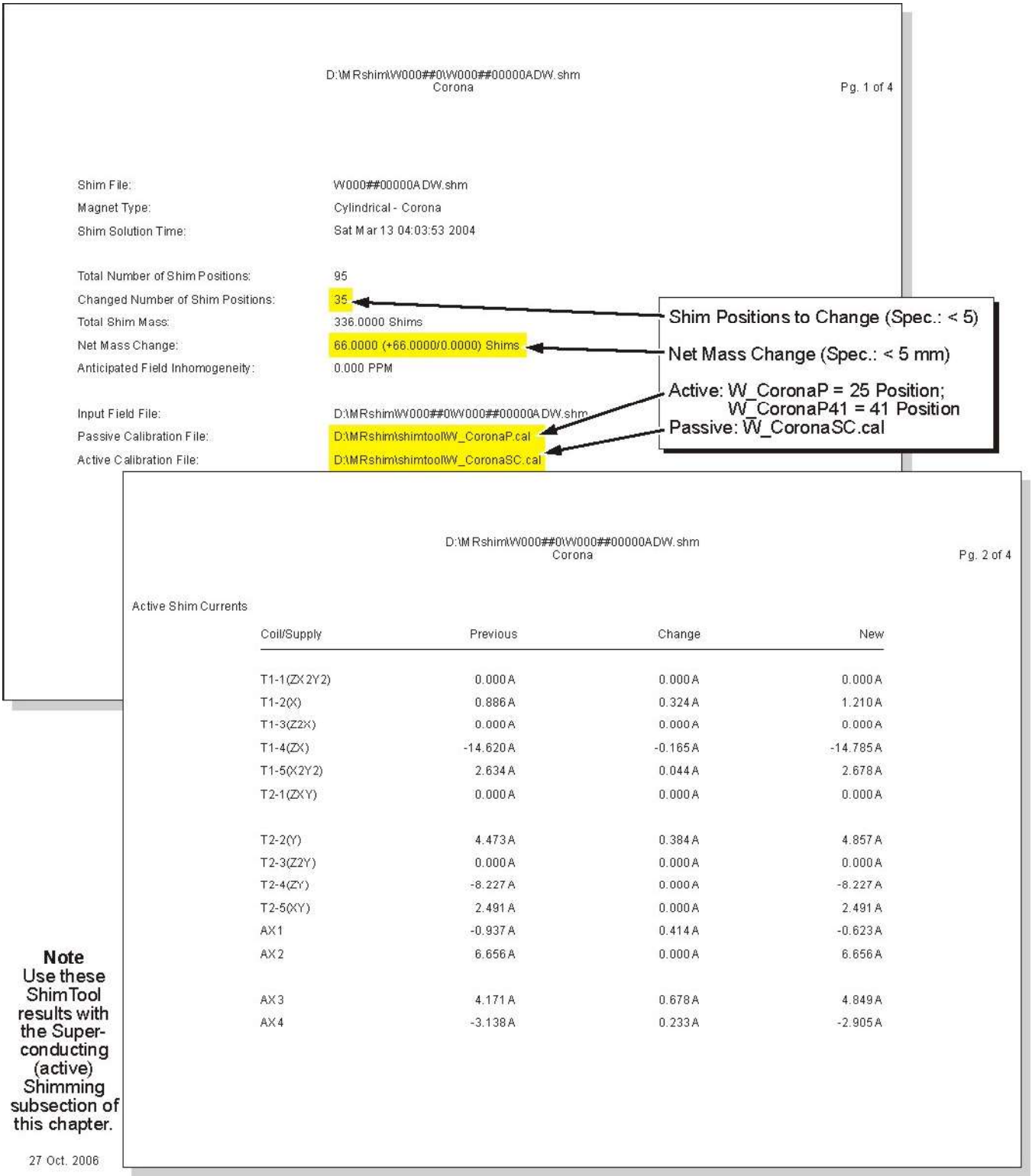


Illustration 3-130: Example ShimTool Printed Report, WB Series LCC300, Pages 1 and 2

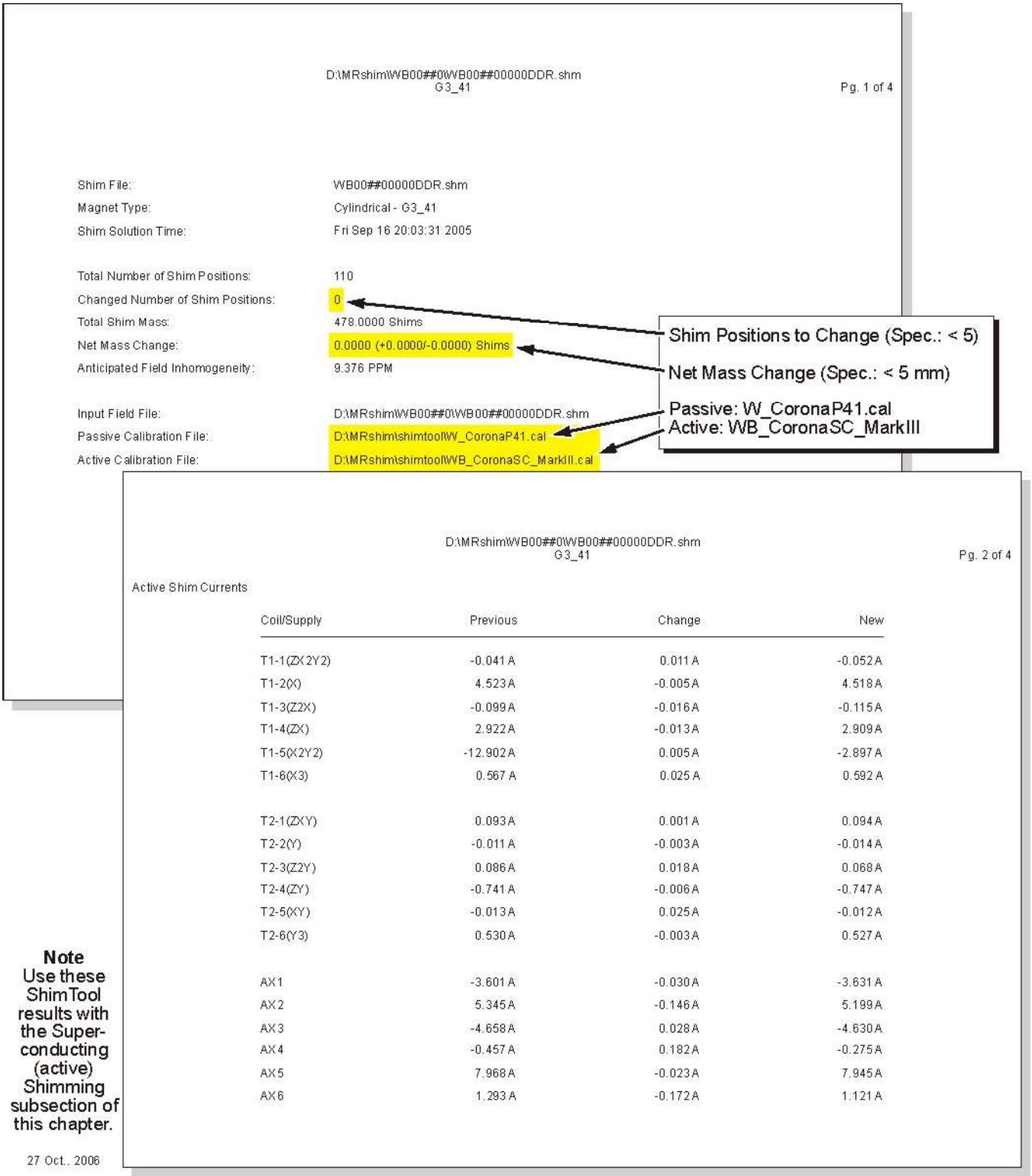


Illustration 3-131: Example ShimTool Printed Report, 25 Position Shim, Pages 3 and 4

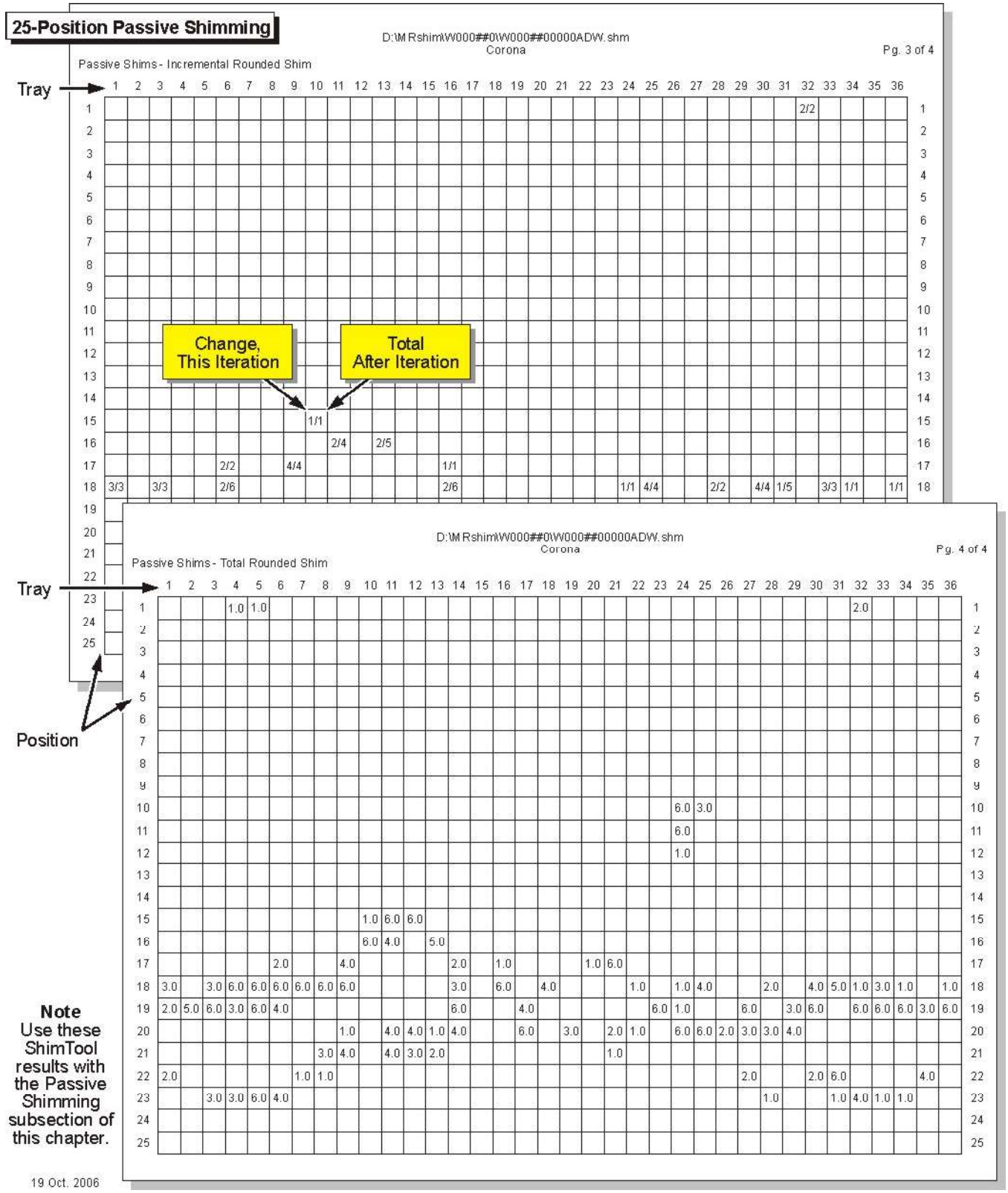
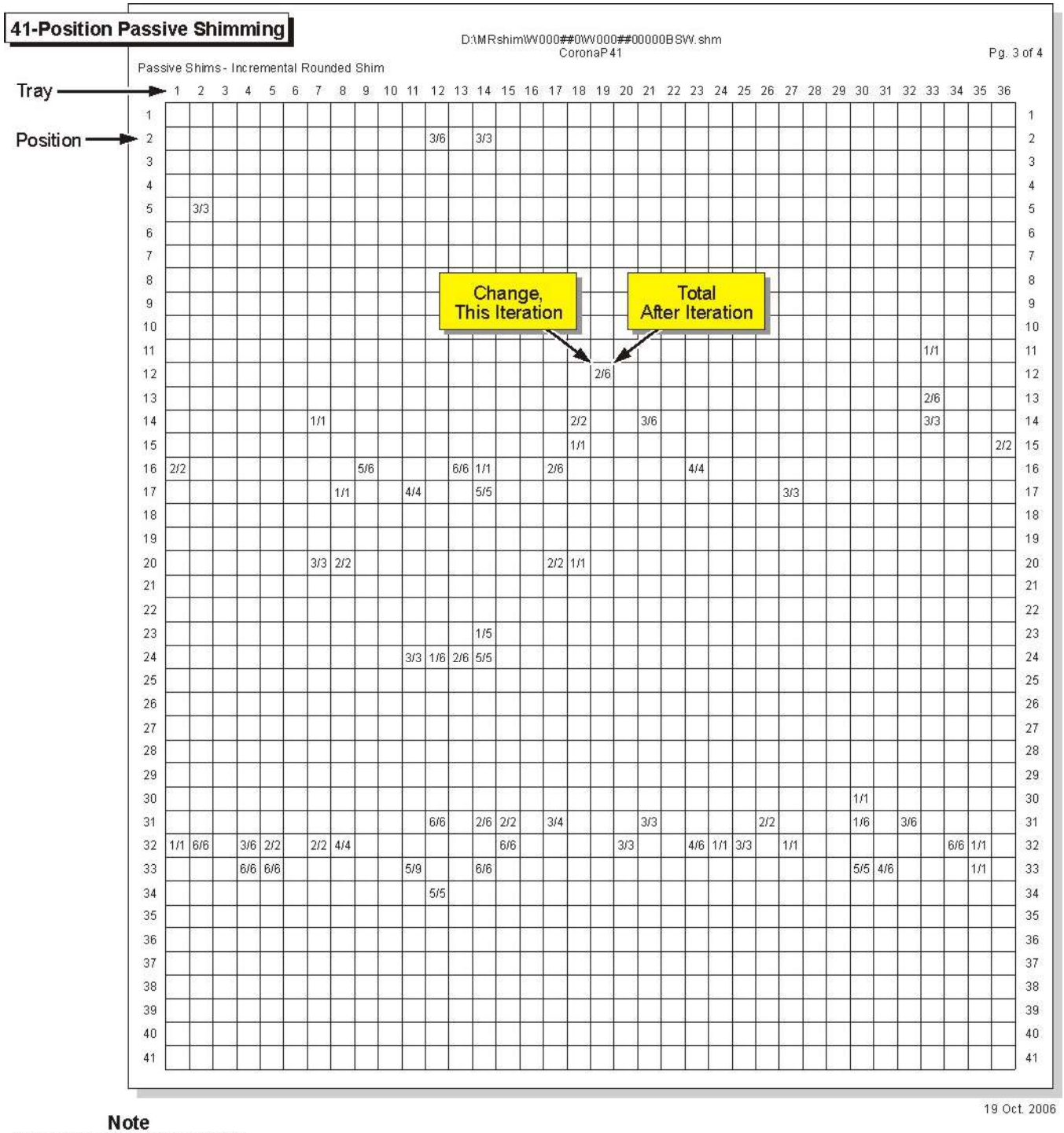
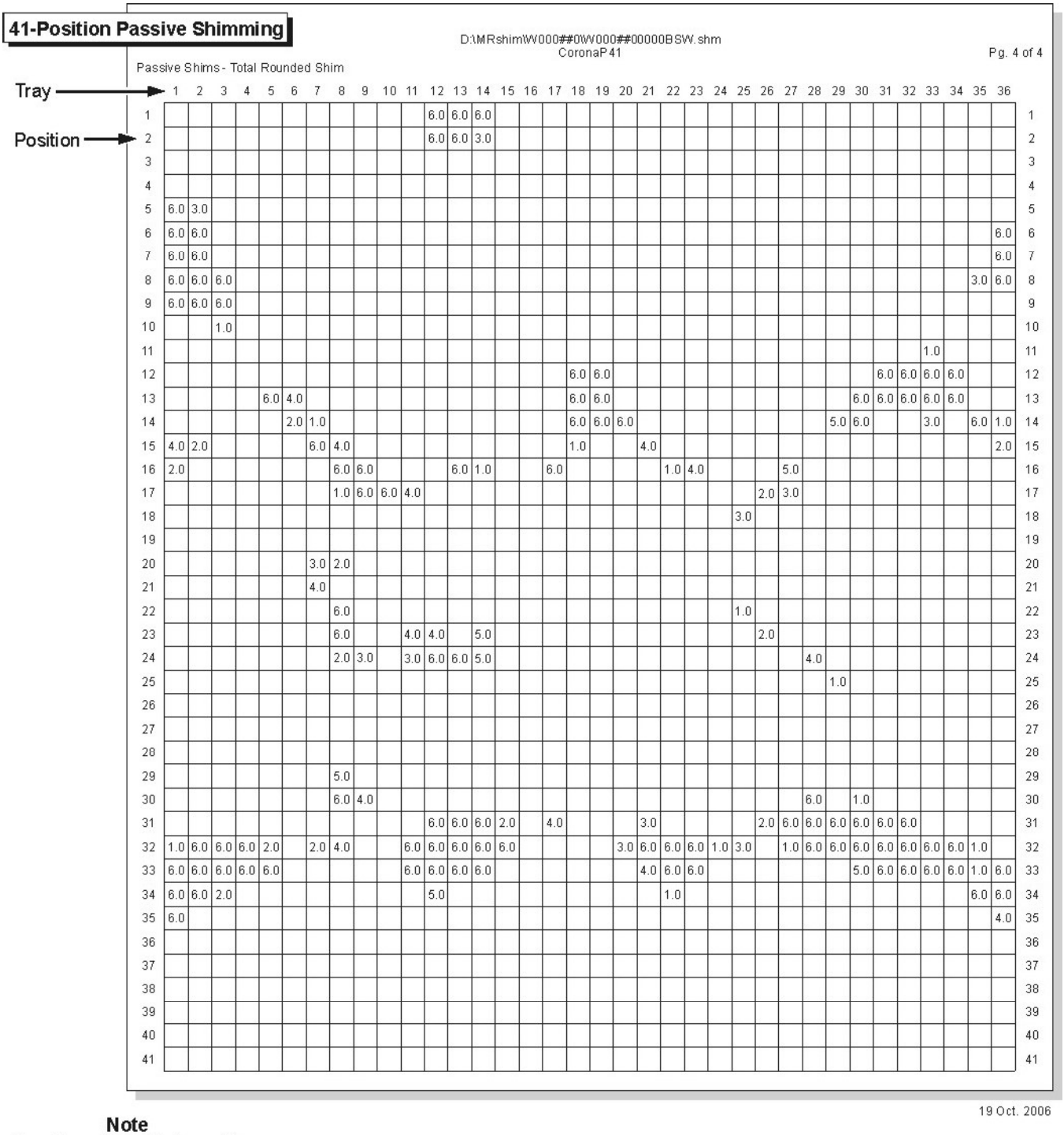


Illustration 3-132: Example ShimTool Printed Report, 41 Position Shim, Page 3



Note
Use these ShimTool results with the Passive Shimming subsection of this chapter.

Illustration 3-133: Example ShimTool Printed Report, 41 Position Shim, Page 4



Note
Use these ShimTool results with the Passive Shimming subsection of this chapter.

3. Record the “Anticipated Field Tolerance (PPM)" value shown in the `.cur / .shm` file in Chapter 8, Shimming Process Data under “Predicted PPM” for the current iteration.

4. Record the "Total Passive Shim Mass (shims)" value shown in the **`.cur / .shm`** file in Chapter 8, Shimming Process Data under "Passive Shim Mass (mm)" for the current iteration.

   NOTE: Shim mass (shims) refers to the total thickness in millimeters of shims in all shim tray positions.

5. On the first iteration, using the centered map set to calculate S/C shimming only, examine the four volumes: 48.0 x 45.0 cm DSV, 40 cm DSV, 30 cm DSV and 20 cm DSV listed under **`The recomp field inhomogeneity is .....`** Compare these values to the specifications shown in Table 3-16.

   NOTE: This step corresponds to the diamond-shaped decision box labelled *Are PPM Values For All 4 Volumes Under "Quantized (Predicted)" Within Spec?* in Illustration 3-96, Shimming Flowchart.

   NOTE: The "45 cm DSV" volume displayed, when the ATR includes Surface Shimming, is not important during field shimming and can be ignored.

Table 3-16: Volumetric Specifications

Volume	Peak-to-Peak PPM Specification
48.0 x 45.0 cm (elliptical) DSV	12.00 ppm
40 cm DSV	4.00 ppm
30 cm DSV	1.20 ppm
20 cm DSV	0.30 ppm

- If **all** four volumes listed under **`The recomp field inhomogeneity is ....`** **are** within specification, then the magnet is shimmed. Continue with Finalization, Step 1.
- If **any** volume listed under **`The recomp field inhomogeneity is ...`** is **not** within specification, compare the "Quantized (Predicted)" values for the four volumes to the specifications shown in Table 3-16.
  - If **all** four volumes listed under **`Quantized (Predicted)`** are within specification:
    1. Apply the S/C shim currents called for by ShimTool in conformance with Section 8.4.5, Superconducting Shimming.
    2. Return to Section 8.4.3.1, Field Map Acquisition, to take a new map and run ShimTool for S/C shimming **only**.
    3. Continue with Step 7.
  - If **any** volume listed under **`Quantized (Predicted)`** is **not** within specification:
    1. Return to Section 8.4.3.2, Acquiring a Shim File, and run ShimTool for **both** passive and S/C shimming.
    2. Continue with Step 6.

6. After running ShimTool set for both passive and S/C shimming, examine the *Net Mass Change* and the *Changed Number of Shim Positions* values in the ShimTool reports summary shown in: Illustration 3-125, printed `.cur / .shm` files shown in Illustration 3-127 and Illustration 3-128 or ShimTool-printed shown in: Illustration 3-129 through Illustration 3-133. Compare these values to the specifications shown in Table 3-17.

   NOTE: This step corresponds to the diamond-shaped decision box labelled *Passive Shim Change < 5 mm and < 5 Positions?* in Illustration 3-96, Shimming Flowchart.

Table 3-17: Passive Shim Change Specifications

Measure	Specification
Net Mass Change	<5 mm
Changed Number of Shim Positions	<5 Positions

   - If the specifications in Table 3-17 were **not** met (either Net Mass Change is ≥5 mm or Changed Number of Shim Positions is ≥5):
     1. Install the passive shims called for by ShimTool in conformance with Section 8.4.4, Passive Shimming.
     2. Once the passive shims are installed, apply the S/C shim currents called for by ShimTool in conformance with Section 8.4.5, Superconducting Shimming.
     3. Return to Section 8.4.3.1, Field Map Acquisition, to take a New map and run ShimTool for **both** passive and S/C shimming.
     4. Repeat Step 6.
   - If the specifications in Table 3-17 were **met** (both Net Mass Change is <5 mm and Changed Number of Shim Positions is <5):
     1. Return to Section 8.4.3.2, Acquiring a Shim File, to run ShimTool for S/C shimming **only**.
     2. Apply the S/C shim currents called for by ShimTool in conformance with Section 8.4.5, Superconducting Shimming.
     3. Return to Section 8.4.3.1, Field Map Acquisition, to take a New map and run ShimTool for S/C shimming **only**.

7. Examine the ShimTool text file's four volumes (48.0 x 45.0 cm DSV, 40 cm DSV, 30 cm DSV and 20 cm DSV) listed under `The recomp field inhomogeneity...` (Illustration 3-127 and Illustration 3-128). Compare these values to the specifications shown in Table 3-16.

   - If **any** volume is not within specification, return to Section 8.4.3.1, Field Map Acquisition, to take a New map and run ShimTool for S/C shimming **only**.
   - If **all** volumes are within specification, the screen shown in Illustration 3-134 will display.
     1. Click [No].

2. Exit ShimTool and continue with Finalization, Step 1.

NOTE: The *Congratulations* screen means the magnet is shimmed to specification. Writing an ATR file is not needed after the magnet has left the factory.

Illustration 3-134: Congratulations Screen

8.4.4 Passive Shimming

8.4.4.1 Shim Tray Removal

1. Do **not** attempt to passive shim a 3.0T magnet without reading, understanding and following these safety alerts:

DANGER
POTENTIAL FATAL INJURY!

MAKE SURE TO REVIEW AND FULLY UNDERSTAND ALL SUPERCONDUCTING MAGNET PORTIONS OF CHAPTER 1, MR MAGNET - SAFETY REQUIREMENTS BEFORE STARTING TO PASSIVE SHIM THE MAGNET.

DANGER
POTENTIAL FATAL INJURY!

MAKE SURE TO FULLY COMPLY WITH ALL REQUIRED ITEMS FOR THE SHIMMING PROCEDURE IN THE 'MAGNET & CRYOGEN SERVICE SAFETY REQUIREMENTS' SUBSECTION OF CHAPTER 1, MR MAGNET - SAFETY REQUIREMENTS BEFORE AND WHILE PERFORMING MAGNET PASSIVE SHIMMING.

DANGER
POTENTIAL FATAL INJURY!

HAVE ALL "WORK ASSISTANTS" OR "WORK OBSERVERS" COMPLY WITH THE 'BUDDY SYSTEM REQUIREMENTS & CERTIFICATION' SUBSECTION OF CHAPTER 1, MR MAGNET - SAFETY REQUIREMENTS BEFORE STARTING TO PASSIVE SHIM THE MAGNET.

⚠WARNING

POTENTIAL PROJECTILE HAZARD

FERROMAGNETIC OBJECTS IN A STRONG MAGNETIC FIELD CAN BECOME DANGEROUS PROJECTILES. STEEL SHIMS IN A MAGNETIC FIELD ARE SUBJECT TO A FORCE PROPORTIONAL TO THE STEEL'S MASS AND TO THE FIELD'S STRENGTH. IN A 3 TESLA FIELD FORCES >50 POUNDS (22.6 KG) MAY BE ENCOUNTERED. AN ATTRACTING FORCE PULLING A SHIM TRAY INTO THE MAGNET WILL BE ENCOUNTERED WHEN A LOADED TRAY IS BROUGHT WITHIN 3 FEET (1 METER) OF THE MAGNET BORE. AN ATTRACTING AND/OR REPELLING FORCE WILL BE ENCOUNTERED WHEN INSERTING/REMOVING A LOADED SHIM TRAY INTO/FROM A TRACK INSIDE THE MAGNET BORE. A REPELLING FORCE ON A SHIM TRAY INSIDE THE MAGNET'S BORE MAY PROPEL THE TRAY OUT FROM THE MAGNET WHEN THE TRAY IS RELEASED FROM ITS FIXED POSITION.

MAKE SURE TO FOLLOW THESE SAFETY REQUIREMENTS DURING PASSIVE SHIM INSTALLATION/REMOVAL:

- **ASSEMBLE ALL EQUIPMENT AND CHECK FUNCTIONALITY IN CONFORMANCE WITH THE PASSIVE SHIM INSTALLATION PROCEDURE.**
- **LOAD SHIM TRAYS OUTSIDE THE MAGNET ROOM & NEVER LOOSE INDIVIDUAL SHIMS INSIDE THE MAGNET ROOM.**
- **SECURE SHIMS IN SHIM TRAYS AND INSTALL TRAYS INTO THE MAGNET IN STRICT CONFORMANCE WITH THE PASSIVE SHIM INSTALLATION PROCEDURE.**
- **WEAR SAFETY GOGGLES/GLASSES DURING SHIM TRAY INSTALLATION/REMOVAL TO PREVENT EYE INJURY FROM SUDDEN TRAY MOVEMENT.**
- **WEAR LEATHER GLOVES DURING SHIM TRAY INSTALLATION/REMOVAL TO PREVENT SKIN INJURY FROM FIBERGLASS SLIVERS.**
- **HOLD SHIM TRAYS FIRMLY IN PLACE WHEN RELEASING INSTALLED TRAYS AND MAKE SURE ALL LOADED SHIM TRAYS ARE RESTRAINED (BY HAND, SHIM TRAY PULLER OR FIXED INTO ITS TRACK), ESPECIALLY TRAYS MARKED ON THE END FLANGE AS MOUNTED IN AN OUTWARD REPELLING FORCE.**
- **INSERT/REMOVE SHIM TRAYS WITH A GRADUAL MOTION.**
- **MAKE SURE TWO PEOPLE ARE AVAILABLE TO INSTALL/REMOVE TRAYS.**
- **DO NOT LOAD SHIM TRAYS WHILE ANYONE IS DIRECTLY IN LINE WITH THE TRAY ON EITHER END OF THE MAGNET, AND**
- **NEVER POSITION YOURSELF BETWEEN A SHIM TRAY AND THE MAGNET.**

- A CLEAR PATH PER CHAPTER 1, MR MAGNET - SAFETY REQUIREMENTS IS REQUIRED FOR PASSIVE SHIM REMOVAL AND INSERTION.

⚠CAUTION

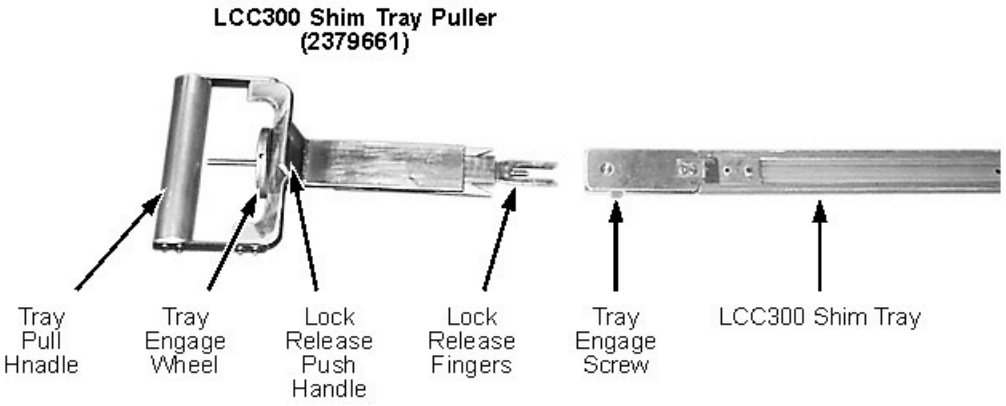
Potential Skin Injury
Fiberglass from the shim trays can splinter while inserting/removing trays. Wear nonslip gloves during shim tray insertion/removal to protect against fiberglass splinters from the trays.

NOTICE

The LCC300 Field Mapping Fixture's patient end support bracket will have to be detached from the magnet in conformance with Preparations for Field Measurement while accessing the shim trays behind it and reattached before further mapping.

2. Align LCC300 Shim Tray Puller 2379661 with the shim tray to be pulled. (See the illustration below.)

Illustration 3-135: Align Shim Tray Puller with Shim Tray

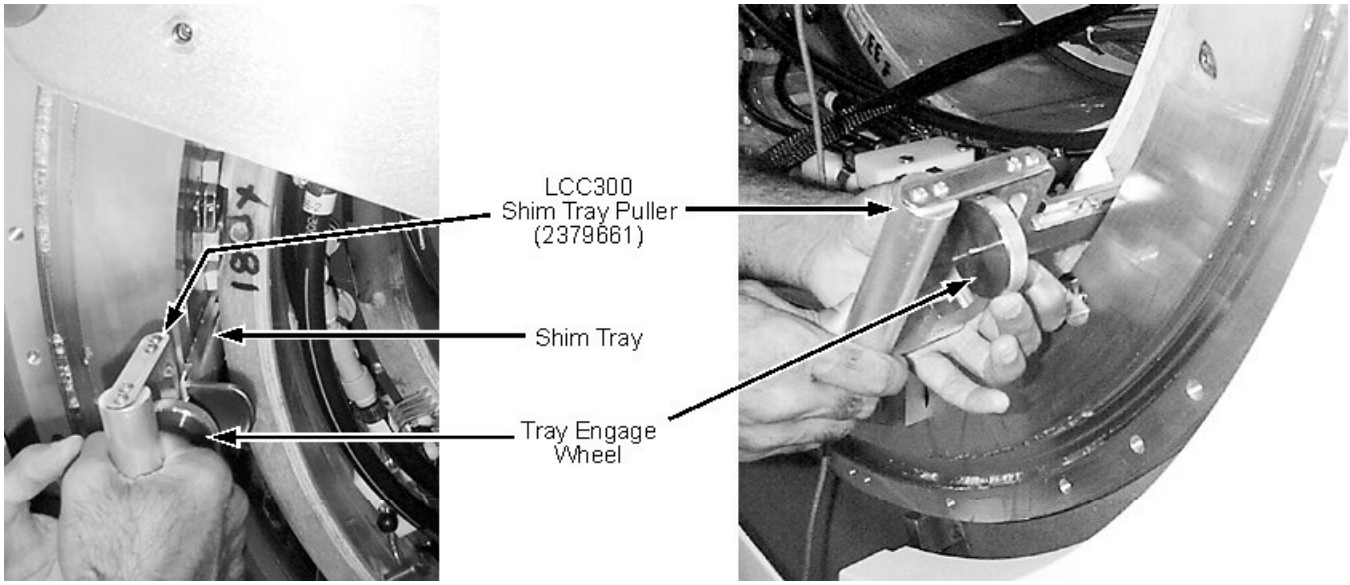


NOTICE

The shim tray puller MUST be fully and solidly engaged with the shim tray.

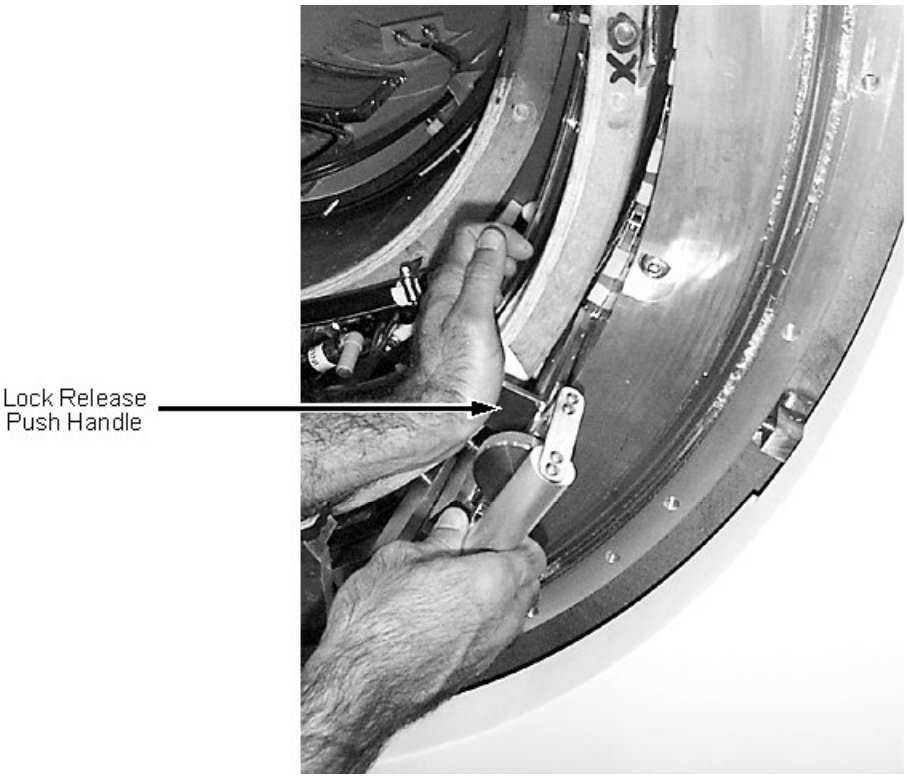
3. Insert the shim tray puller's tray engage screw into the threads at the end of the shim tray, then turn the puller's tray engage wheel to fully engage the screw with the tray. (See the following illustration.)

Illustration 3-136: Engage Shim Tray Puller with Shim Tray



4. Push the shim tray puller's push handle to release the locking prongs on the tray. (See Illustration 3-135 and Illustration 3-137.)

Illustration 3-137: Release Shim Tray Puller



⚠CAUTION

Potential Projectile Hazard

Ferromagnetic objects in a strong magnetic field can become dangerous projectiles.

Be prepared to manage the effects of a 3.0T field on the shim tray during tray insertion/removal. Adhere to all safety material listed above.

⚠CAUTION

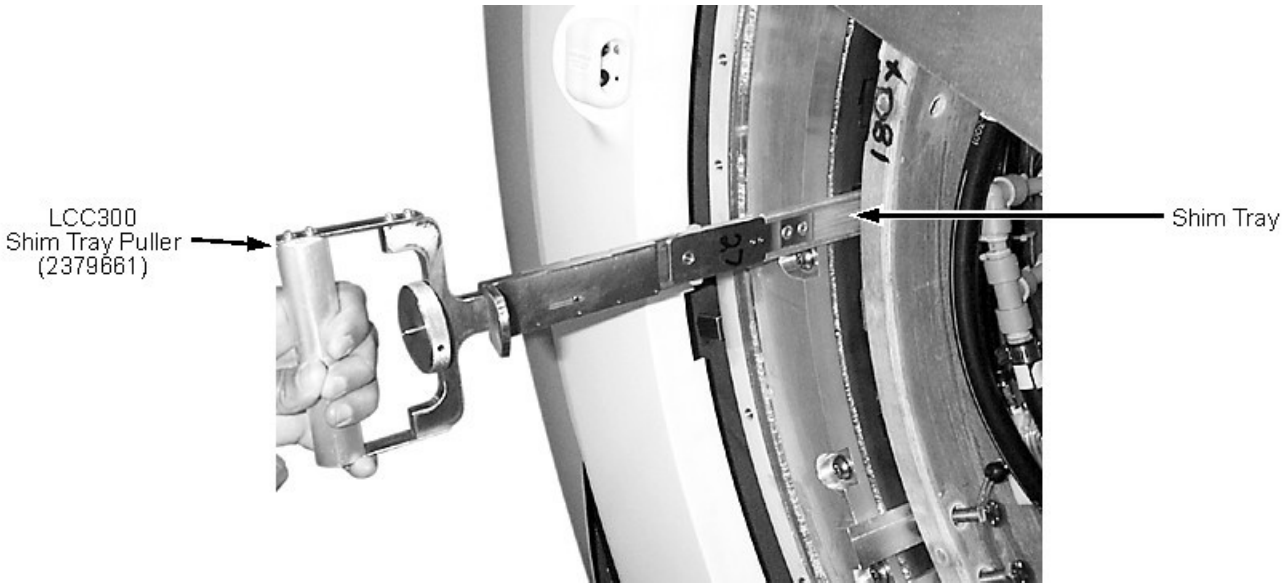
Potential Skin Injury

Fiberglass from the shim trays can splinter while inserting/removing trays.

Wear nonslip gloves during shim tray insertion/removal to protect against fiberglass splinters from the trays.

5. Carefully slide the shim tray straight out from its track. Have the work assistant hold onto the tray as soon as possible.

Illustration 3-138: Shim Tray Removal



6. Work Assistant: Securely hold the shim tray, and carry it and the puller away from the magnet's field to a shim tray loading area in another room.

8.4.4.2 Loading Passive Shims

NOTICE

Load shims into the shim tray in a room away from the magnet's field.

1. **First person:** Identify which component shims are required to meet the total shim mass specified by ShimTool for each position in each tray.

NOTE: See Illustration 3-139 for a sample ShimTool shimming report, Illustration 3-140 for the LCC300 shim tray layout, and Illustration 3-141 for assembly of component shim per shim position. Illustration 3-139 shows the `C:` drive directory paths used by Windows 2000 ShimTool installations. Windows XP installations use `D:` drive directory paths instead.

Illustration 3-139: Example ShimTool Printed Report (Pages 3 and 4 of 25-Position Report)

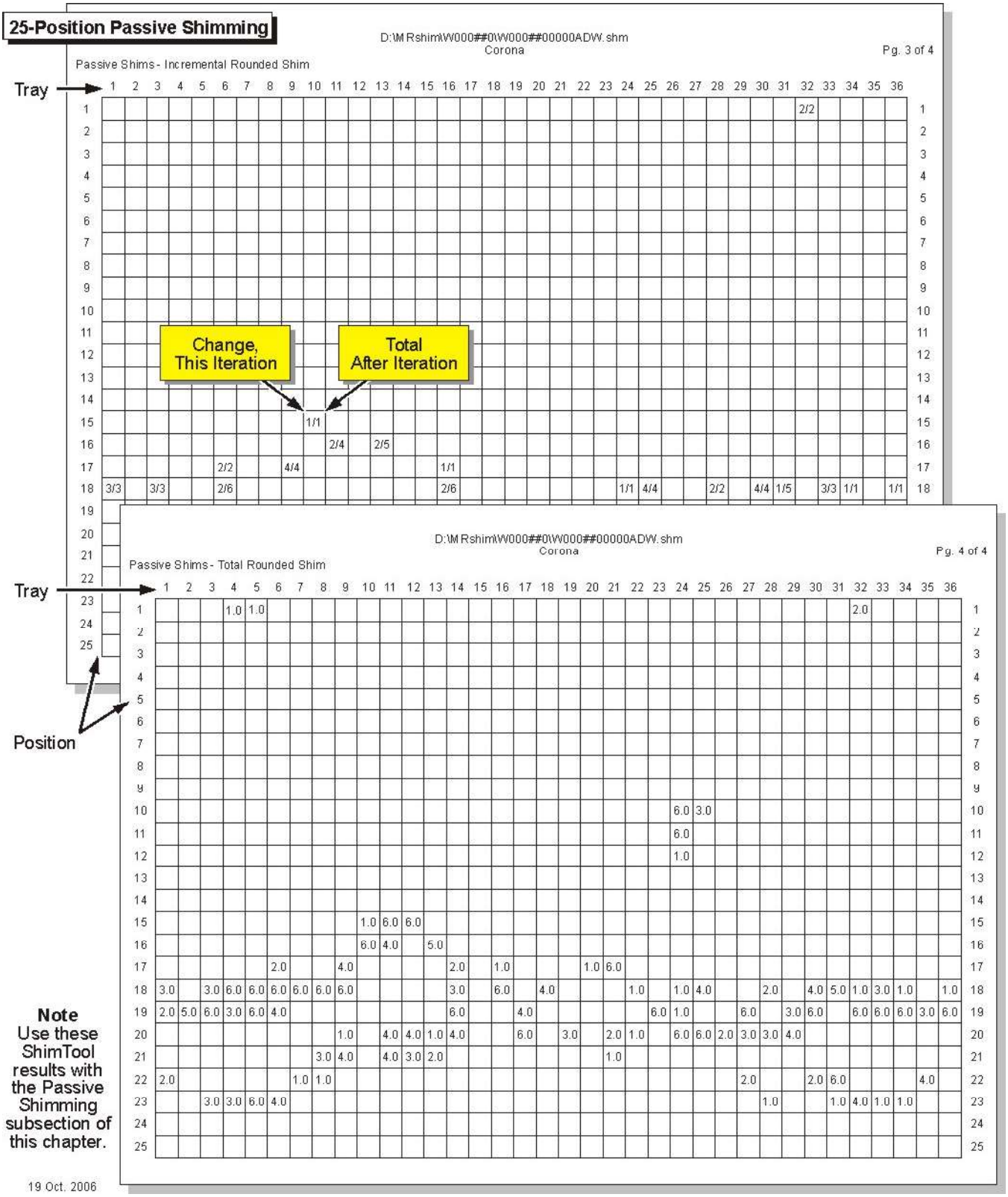


Illustration 3-140: Shim Tray Layout

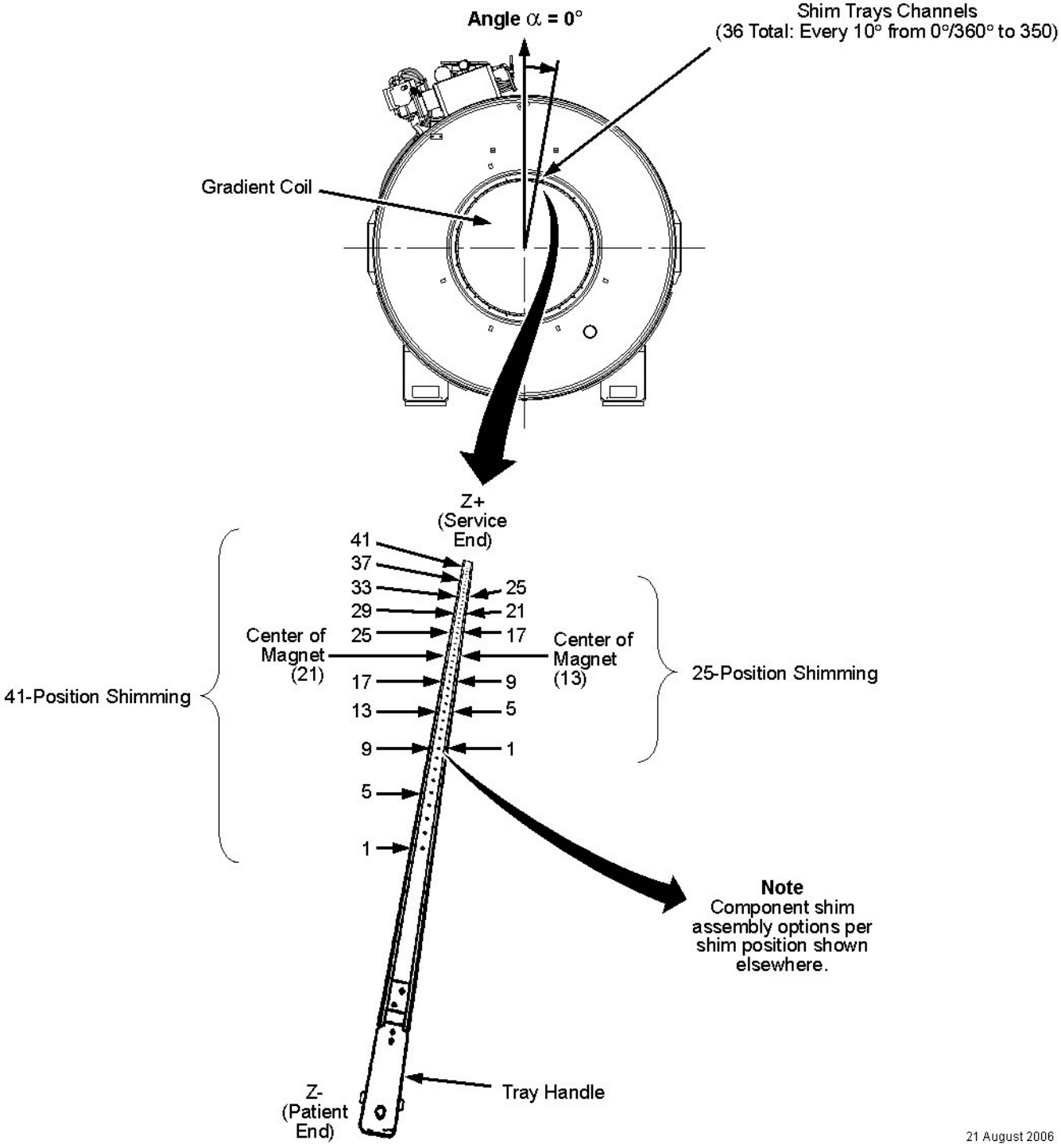
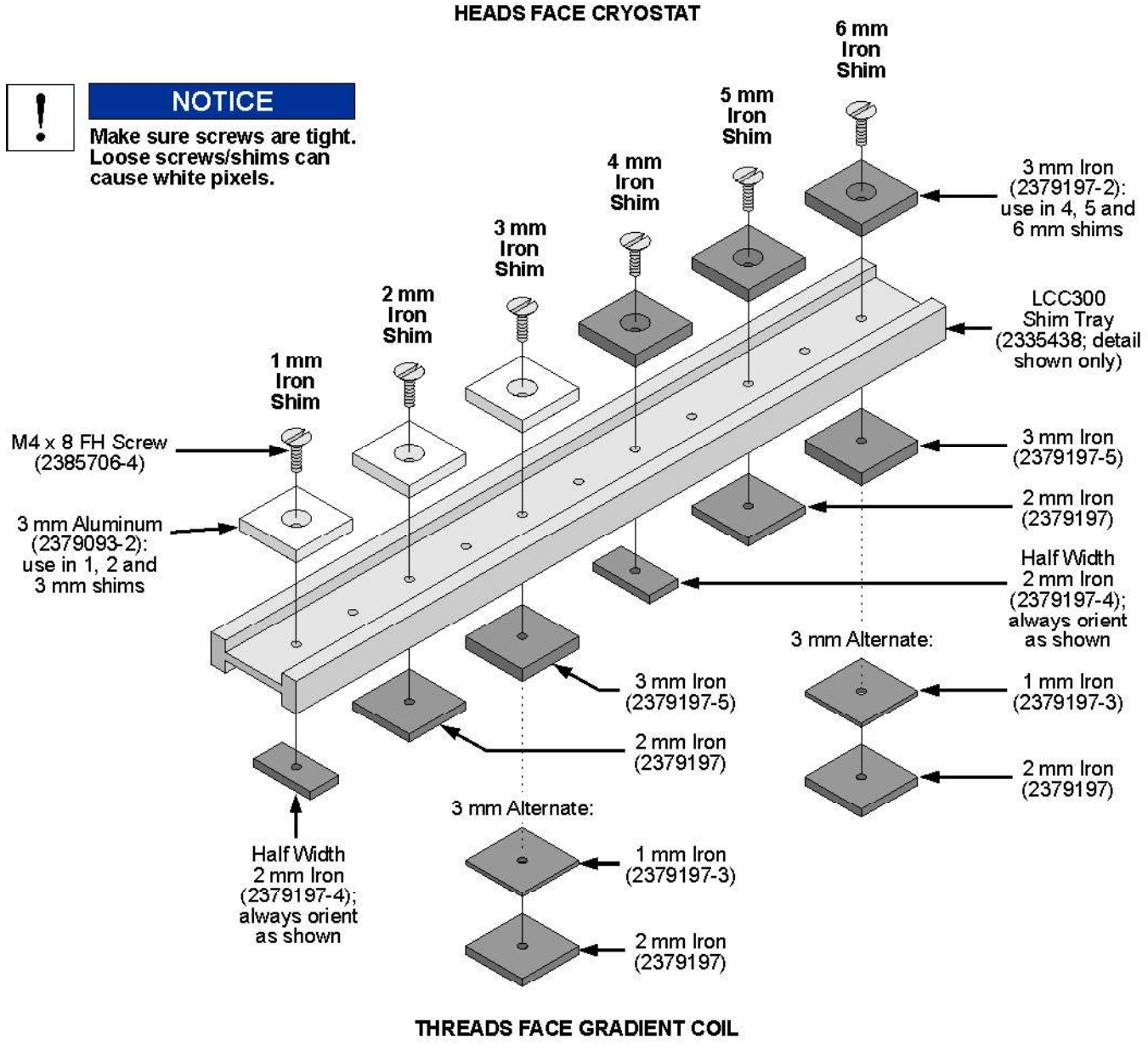


Illustration 3-141: Assembly of Component Shims Per Shim Position



NOTICE

Make sure screws holding shims to shim tray are fully tightened. Use Torque Screwdriver 46-294167P81. Loose screws/shims can cause white pixels.

2. Securely screw the component shim arrangement to the shim tray position as shown in Illustration 3-141. Torque each screw to 10 inch-pounds using torque screwdriver 46-294167P81 (included in LCC300 Passive Shimming Kit 2386029). Orient every position in each tray identically (screw heads facing the same way, etc.)

3. **Second person (not the first):** Verify that incremental shims were added/subtracted in conformance with the “Passive Shims - Incremental Rounded Shim” information on Page 3 of ShimTool's printout. (Illustration 3-139).

NOTICE

Do NOT change the name of the `.shm` file. During the next shimming iteration ShimTool uses the steel quantity/location information from this iteration's .shm file and a new map of the field with that steel installed to calculate its new report.

4. **Both people separately:** Verify that the total shims at each tray position equals the total shims for that tray position specified in the “Passive Shims - Total Rounded Shim” information on Page 4 of ShimTool's printout (shown in Illustration 3-139).

   - If the actual shim totals in each position **match** ShimTool's printout/`.shm` file, then continue with Section 8.4.4.3, Shim Tray Insertion.
   - If the actual shim totals do **not** match ShimTool's printout/`.shm` file in any position:

     1. Edit this iteration's `.shm` file's “Total - Quantized” pages to reflect the actual steel on the trays.
     2. Save the edited `.shm` file using its **existing** name.
     3. Continue with Section 8.4.4.3, Shim Tray Insertion.

8.4.4.3 Shim Tray Insertion

⚠CAUTION

Potential Skin Injury
Fiberglass from the shim trays can splinter while inserting/removing trays. Wear nonslip gloves during shim tray insertion/removal to protect against fiberglass splinters from the trays.

NOTICE

Field-supplied flexible plastic sheets must be free of sharp edges and bent corners.

1. If 10 mil thick flexible plastic sheets (x-ray film, mylar or equivalent), 10 in. x 14 in. (250 mm x 350 mm) minimum are available, bend 1.5 in. (40 mm) of one short edge to ~ 90°. Carefully slide the sheet between the shim tray guide of the tray to be inserted and the gradient coil wrap to protect the gradient coil wrap from damage.

NOTICE

Reconnect the shim tray puller to the shim tray in a room away from the magnet's field.

2. Screw the shim tray puller to the end of the shim tray.

⚠CAUTION

Potential Projectile Hazard

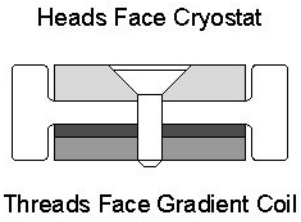
Ferromagnetic objects in a strong magnetic field can become dangerous projectiles.

Be prepared to manage the effects of a 3.0T field on the shim tray during tray insertion/removal. Adhere to all safety material listed above.

3. Securely carry the puller and tray to the magnet.

4. Align the end of the shim tray with the tray's track. Orient every tray in conformance with Illustration 3-142.

Illustration 3-142: Proper Shim Tray Orientation



⚠CAUTION

Potential Pinch Hazard

Fingers can get pinched during tray insertion when magnetic field pulls tray into magnet.

Guide trays into the tracks using a flat hand or fist, not fingers. (See Illustration 3-143.)

NOTICE

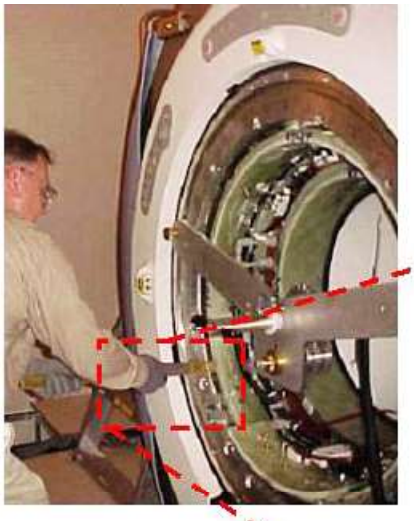
Make sure the passive shim trays do not touch the gradient coil wrap during insertion to prevent damage to the gradient coil wrap.

5. Begin to carefully slide the shim tray straight into its track using a flat hand or fist as in the following illustration. Have the work assistant help guide the tray into the track. Visually make sure the tray does not touch the gradient coil wrap as the tray enters the track.

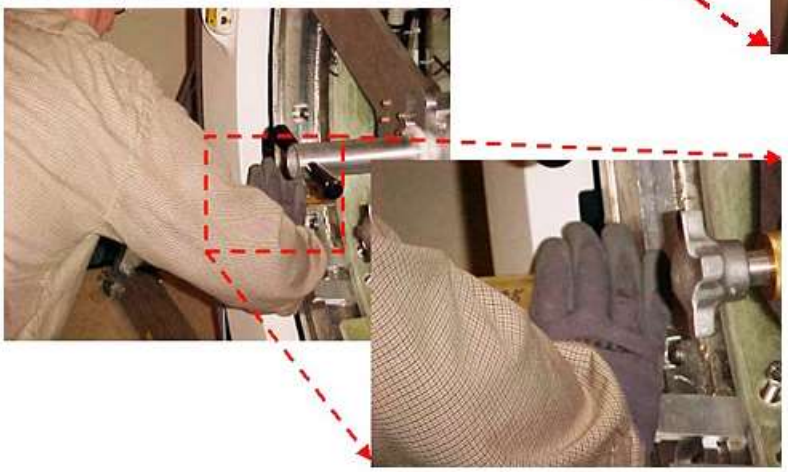
Illustration 3-143: Hand Guidance of Shim Tray Insertion

A finger can get pinched if incorrect hand positioning is used on a shim tray when the tray is being inserted into a LCC300 magnet.

This is due to the force in the magnetic field pulling the tray into the magnet.



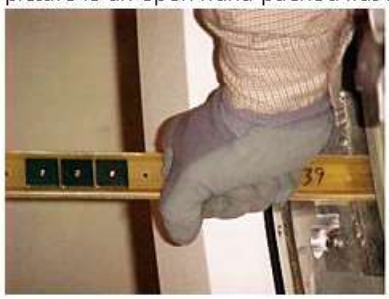
Note the positioning of the hand on the shim tray. The hand can quickly be pulled from the tray when the tray is pulled into the magnet.



The hand that guides the tray into the magnet should be flat against the tray as seen below.

Different locations on the shim drum will require some repositioning of the hands, but the guide fingers should always be flat against the shim tray.

Here are two examples of the guide hand guiding a tray into the magnet. The left picture is a fist pushed flat against the shim tray, and the right picture is an open hand pushed flat against the shim tray.



6. Pull the shim tray puller's push handle back to allow the locking prongs on the tray to re-engage.

7. Turn the shim tray puller's wheel until the puller is disengaged from the tray.

8.4.5 Superconducting Shimming

1. Do **not** attempt to superconductive shim a 3.0T magnet without reading, understanding and following these safety alerts and notices:

DANGER
POTENTIAL FATAL INJURY!

MAKE SURE TO REVIEW AND FULLY UNDERSTAND ALL SUPERCONDUCTING MAGNET PORTIONS OF CHAPTER 1, MR MAGNET - SAFETY REQUIREMENTS BEFORE STARTING TO S/C SHIM THE MAGNET.

DANGER
POTENTIAL FATAL INJURY!

MAKE SURE TO FULLY COMPLY WITH ALL REQUIRED ITEMS FOR THE SHIMMING PROCEDURE IN THE 'MAGNET & CRYOGEN SERVICE SAFETY REQUIREMENTS' SUBSECTION OF CHAPTER 1, MR MAGNET - SAFETY REQUIREMENTS BEFORE AND WHILE PERFORMING S/C SHIMMING THE MAGNET.

DANGER
POTENTIAL FATAL INJURY!

HAVE ALL “WORK ASSISTANTS” OR “WORK OBSERVERS” COMPLY WITH THE 'BUDDY SYSTEM REQUIREMENTS & CERTIFICATION' SUBSECTION OF CHAPTER 1, MR MAGNET - SAFETY REQUIREMENTS BEFORE STARTING TO S/C SHIM THE MAGNET.

WARNING
ASPHYXIATION HAZARD!
THE SHIMMING PROCEDURE GENERATES ODORLESS, COLORLESS HELIUM GAS THAT DISPLACES OXYGEN IN THE AIR.
MAKE SURE MAGNET ROOM VENT EXHAUST FAN IS ON BEFORE STARTING TO S/C SHIM THE MAGNET.

CAUTION
Potential Magnet Quench
A closed Nupro Valve during Shim Lead engagement can cause a magnet quench. Make sure the Nupro Valve is fully open and the valve is frosted before slowly engaging the Shim Lead. Do NOT remove the Shim Lead's Orifice Cap that controls helium gas flow. Always engage/disengage the Shim Lead in conformance with Shim Lead Engagement and Disengagement.

NOTICE

Make sure that the shim power supply is calibrated in conformance with the vendor's manual, and the shim heater currents are set as shown below before use.

- **Transverse 1 Shim Heater Current: 610 mA ±5 mA**
- **Transverse 2 Shim Heater Current: 610 mA ±5 mA**
- **Axial Shim Heater Current: 710 mA ±10 mA**

NOTICE

The "Recommended Total Current" and polarity values calculated by the shim program must be entered into the S/C Correction Coils before performing subsequent field mapping.
The coil groups are:

- **Transverse Coils, Odd: T1-1 to T1-6**
- **Transverse Coils, Even: T2-1 to T2-6**
- **Axial Coils: AX1 to AX6**

Each coil group is connected to one heater circuit on the shim power supply. Therefore, if the only current change was in the Axial 2 Coil, turning the Axial Switch Heater on would dump the currents in Axial Coils (AX1 to AX6) and the appropriate currents for each Axial Coil would need entering.

NOTICE

Before turning on the shim coil power supply and applying shim currents, make sure the following conditions exist to prevent irreparable damage to the vapor-cooled Shim Leads:

- **Orifice on the Shim Lead Nupro Vent Valve is in place.**
- **Shim Lead is frosting and venting.**
- **Shim Power Supply current controls are set to zero (fully CCW).**

NOTICE

Do NOT move articles or equipment in the Magnet Room while adjusting shim currents.

2. Make sure the Shim Lead is engaged (Shim Lead Engagement and Disengagement), the Shim Lead Nupro Vent Valve is open, vapor is escaping from the Shim Lead and the lead is frosted, then turn on the power supply.

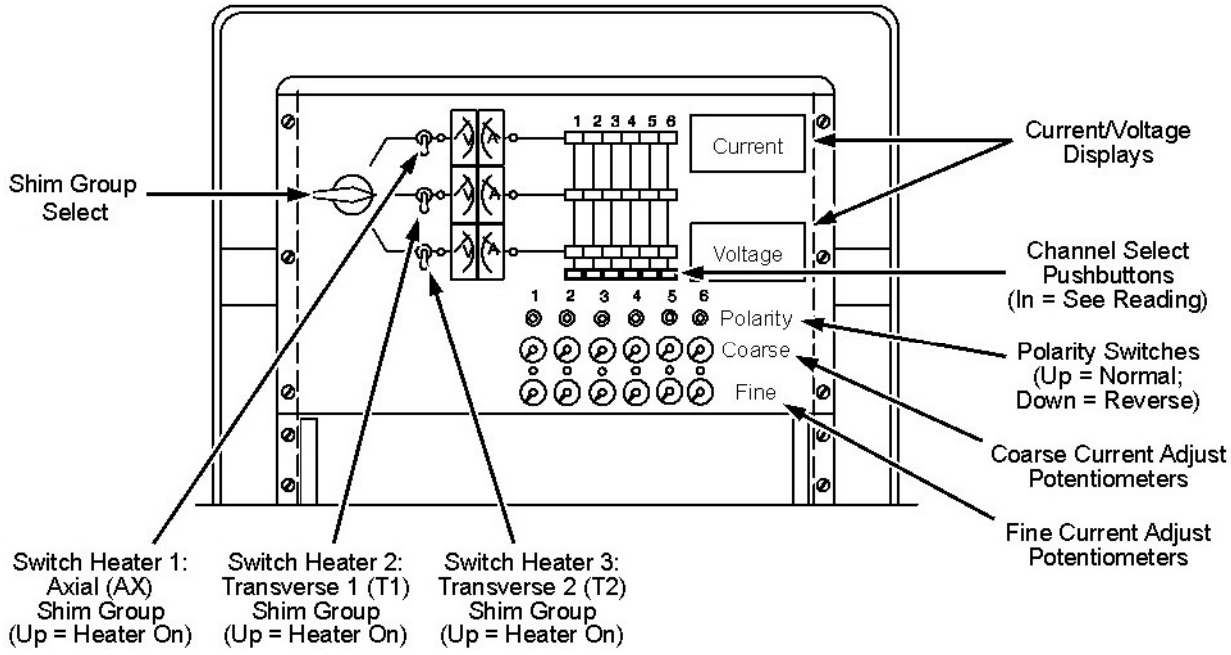
3. Repeat the following steps: Step 3.athrough Step 3.h to input shim currents for each shim group in sequence: T1, then T2 and Axial. (See Table 3-18.)

a. Set the Shim Group Select Switch to the appropriate group: T1, T2 or Axial. (See Illustration 3-144.)

Table 3-18: S/C Shim Groups

	Transverse 1 Shim Group	Transverse 2 Shim Group	Axial Shim Group
Course/Fine Adjust Potentiometer & Polarity Light/Switch	"Shim Group Select" Switch Setting		
	Middle	Bottom	Top
	Coil (Circuit)	Coil (Circuit)	Coil (Circuit)
1	T1-1 (Z X^2Y^2)	T2-1 (ZXY)	AX1 (Z^1)
2	T1-2 (X)	T2-2 (Y)	AX2 (Z^2)
3	T1-3 (Z^2X)	T2-3 (Z^2Y)	AX3 (Z^3)
4	T1-4 (ZX)	T2-4 (ZY)	AX4 (Z^4)
5	T1-5 (X^2Y^2)	T2-5 (XY)	AX5* (Z^5)*
6	T1-6 (X^3)*	T2-6 (Y^3)*	AX6* (Z^6)*
* Not applicable to W0 Series LCC300 magnets.			

Illustration 3-144: Shim Power Supply Controls (Front Panel)



NOTE: The present current/polarity, referred to in the following steps, is the current/polarity that presently exists in each shim coil. The present currents/polarities are those ShimTool calculated/reported (in the *Previous* column under *Active Shim Currents* shown in Illustration 3-145 or Illustration 3-146) in its previous iteration, and then loaded into the shim coils and recorded in Chapter 8, SC Shimming Data in the *New* column.

Illustration 3-145 and Illustration 3-146 show the `C:` drive directory paths used by Windows 2000 ShimTool installations. Windows XP installations use `D:` drive directory paths instead.

Illustration 3-145: Example ShimTool Printed Report, W Series LCC300, Pages 1 and 2

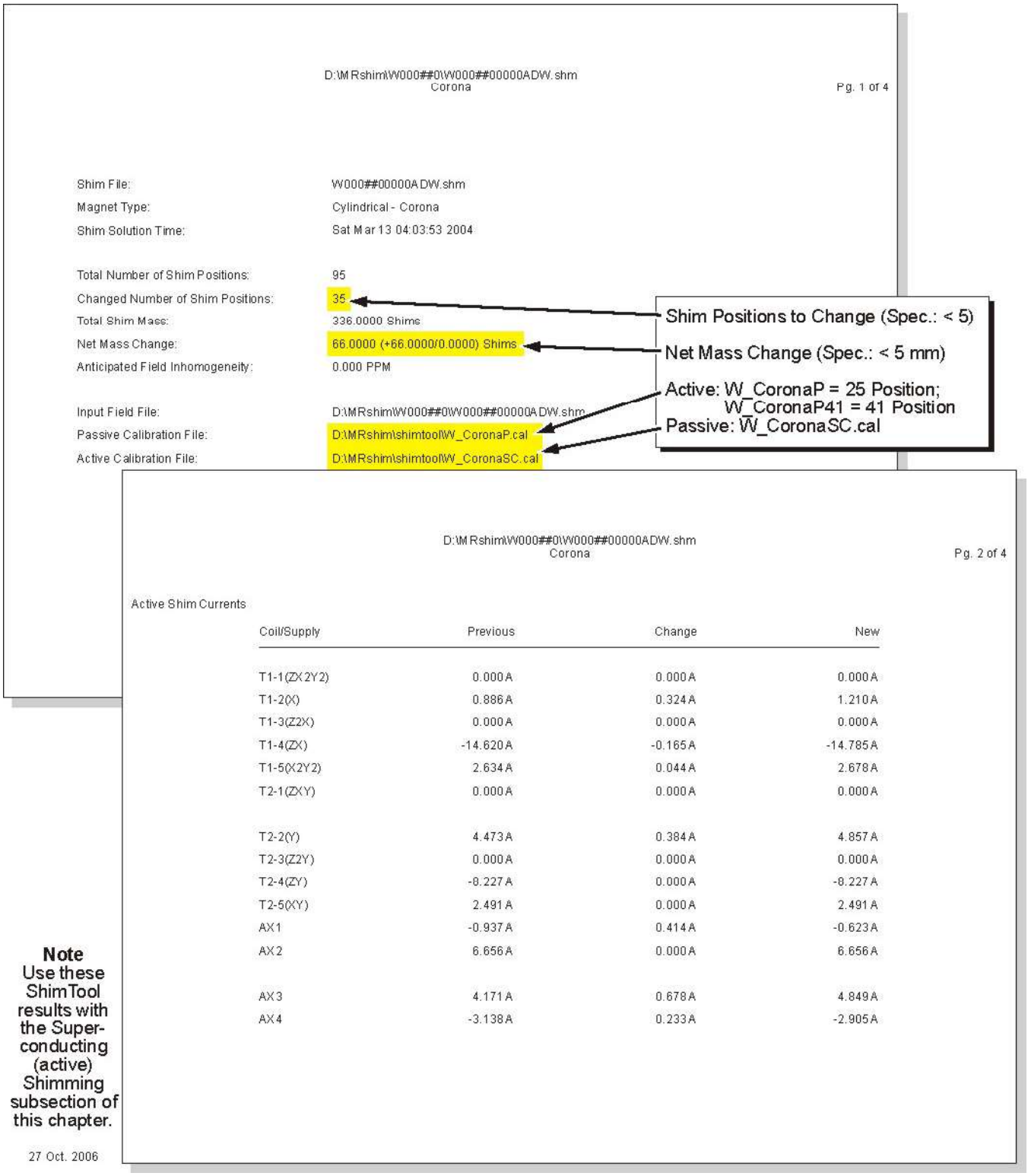


Illustration 3-146: Example ShimTool Printed Report, WB Series LCC300, Pages 1 and 2

D:\MRshim\WB00##0\WB00##00000DDR.shim
G3_41
Pg. 1 of 4

Shim File:	WB00##00000DDR.shim
Magnet Type:	Cylindrical - G3_41
Shim Solution Time:	Fri Sep 16 20:03:31 2005
Total Number of Shim Positions:	110
Changed Number of Shim Positions:	0
Total Shim Mass:	478.0000 Shims
Net Mass Change:	0.0000 (+0.0000/-0.0000) Shims
Anticipated Field Inhomogeneity:	9.376 PPM
Input Field File:	D:\MRshim\WB00##0\WB00##00000DDR.shim
Passive Calibration File:	D:\MRshim\shimtool\W_CoronaP41.cal
Active Calibration File:	D:\MRshim\shimtool\WB_CoronaSC_MarkIII.cal

Shim Positions to Change (Spec.: < 5)

Net Mass Change (Spec.: < 5 mm)

Passive: W_CoronaP41.cal
Active: WB_CoronaSC_MarkIII

D:\MRshim\WB00##0\WB00##00000DDR.shim
G3_41
Pg. 2 of 4

Active Shim Currents

Coil/Supply	Previous	Change	New
T1-1(ZX2Y2)	-0.041 A	0.011 A	-0.052 A
T1-2(X)	4.523 A	-0.005 A	4.518 A
T1-3(Z2X)	-0.099 A	-0.016 A	-0.115 A
T1-4(ZX)	2.922 A	-0.013 A	2.909 A
T1-5(X2Y2)	-12.902 A	0.005 A	-2.897 A
T1-6(X3)	0.567 A	0.025 A	0.592 A
T2-1(ZXY)	0.093 A	0.001 A	0.094 A
T2-2(Y)	-0.011 A	-0.003 A	-0.014 A
T2-3(Z2Y)	0.086 A	0.018 A	0.068 A
T2-4(ZY)	-0.741 A	-0.006 A	-0.747 A
T2-5(XY)	-0.013 A	0.025 A	-0.012 A
T2-6(Y3)	0.530 A	-0.003 A	0.527 A
AX1	-3.601 A	-0.030 A	-3.631 A
AX2	5.345 A	-0.146 A	5.199 A
AX3	-4.658 A	0.028 A	-4.630 A
AX4	-0.457 A	0.182 A	-0.275 A
AX5	7.968 A	-0.023 A	7.945 A
AX6	1.293 A	-0.172 A	1.121 A

Note
Use these ShimTool results with the Super-conducting (active) Shimming subsection of this chapter.

27 Oct., 2006

b. Match the Shim Power Supply current and polarity of each channel (coil) in each group to the present current and polarity in the selected shim coil group. (See Illustration 3-144.)

- Set the Polarity Toggle Switches (Up = normal/positive polarity and Down = reversed/negative polarity) as required for to match the present polarity for the each coil in the group.
- Set the Course/Fine Current Adjust Potentiometers on the power supply to match the present current level for the each coil in the group.

NOTE: The polarity relays will not change polarity if there is any current flowing through their respective channels. The current must be reduced to zero before the relays will change to the position indicated by the external switches on the power supply.

NOTICE

Magnet damage is possible if heater currents are not set correctly.

NOTICE

When the Switch Heaters are turned on, any existing currents in the Shim Coils will be discharged into the power supply. To prevent dumping excessive currents through the Shim Leads, match the existing shim currents at the power supply with those in the magnet before turning on the Switch Heaters. The current then can be adjusted to the required new levels after the Switch Heaters are activated.

c. Verify that all shim power supply currents/polarities match the currents/polarities in the selected shim coil group.

d. Turn on the selected group's Switch Heater (Transverse 1, Transverse 2 or Axial), and wait 30 seconds for the switches to go resistive.

NOTE: If there is a polarity change from the present to the new current, set the current to zero before changing the polarity switch.

e. Set the new “total” currents and polarities for the shim coil group using ShimTool's latest “Active Shim Currents” values (i.e., the currents listed in the column labelled *New* on the *Active Shim Currents* page of the ShimTool report shown in Illustration 3-145).

NOTICE

Since the LCC300 magnet correction coils have a greater time constant (inductance : resistance ratio) than those of a 1.5T magnet, a longer settling time is required for the shim currents. It is important that the shim current settling time is in conformance with Table 3-19 to prevent subsequent current drift after settling.

f. Allow the shim currents to settle for the time shown in Table 3-19.

Table 3-19: Settling Times for New Shim Currents After Re-establishing ATR

Shim Coil Group	Settling Time
T1	10 minutes
T2	
Axial*	20 minutes*
* Axial times represent minimum times. Axial coupling may require longer wait times to meet the magnetic field stabilization requirements stated in Step 5 below.	

g. Verify the new currents, then turn off the heater group and wait five (5) minutes.

h. After waiting five minutes, gradually turn the power supply Current Adjust Potentiometers down to zero.

NOTE: If repeated iterations of the shim program call for the same current increment in a shim coil, indicating the Shim Switch not going resistive, then one of the two following actions may help drive the Shim Switch resistive:

- Make sure the Heater current is set properly, or
- Set 20 amps in the coil, then lower the current to the required value.

Adjust slightly, as required. (1 mA high is better than 1 mA low.)

NOTE: Failure to accurately set the power supply currents and polarity can greatly increase the number of plotting iterations (i.e., time to shim the magnet).

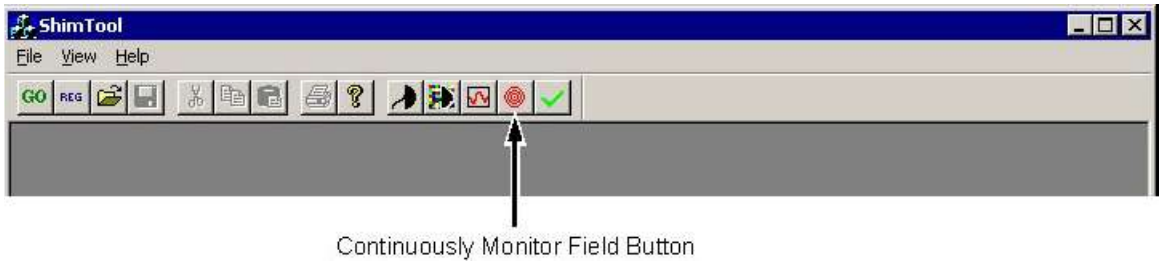
4. Make sure the field camera is in the 0° position.

5. For axial currents **only**, monitor field drift until it stabilizes (i.e., <2 Hz change in total field over a two-minute period):

NOTE: In some cases, the frequency could vary as much as 100 Hz. Shutting off the Coldhead Compressor during acquisition/mapping of shim data may help reduce the frequency change.

a. Click the [Continuously Monitor Field] button (second button from right) from ShimTool's main screen. (See the following illustration.)

Illustration 3-147: Continuously Monitor Field Button on ShimTool Main Screen



b. Select **Probe 22**.

c. Select [Start] on the screen that displays to begin measuring field strength and drift.

d. Record the starting frequency for use in Step 5.e.

e. Wait two minutes, then click [Stop] and record the change between the starting and present frequencies.

- If the change is **<2 Hz**, continue with Step 6.
- If the change is **≥2 Hz**, repeat Step 5.c and Step 5.e.

6. Once the magnetic field is stable, turn off the last Switch Heater that was turned on, and allow the Heater to cool for five (5) minutes.

7. Slowly turn all the Course/Fine Current Adjust potentiometers on the shim power supply back down to zero (0) amps (full CCW).

⚠CAUTION
Potential Quench Hazard
The axial shim currents may quench if the Shim Switch is in the Axial position when the Shim Power Supply is turned off.
Make sure the Shim Power Supply's Shim Switch is in the Transverse 1 or Transverse 2 position before turning it off.

8. When S/C shimming is complete:

a. Turn off the power supply.

⚠WARNING
ELECTRICAL SHOCK HAZARD
CONTACT WITH CONNECTORS LEADING TO AN ENERGIZED POWER SUPPLY CAN CAUSE ELECTRICAL SHOCK.
FOLLOW LOCKOUT/TAGOUT PROCEDURES WHILE MAKING ELECTRICAL CONNECTIONS TO THE SHIM POWER SUPPLY.

b. Disconnect and LOTO input power to the Shim Coil Power Supply. Verify that no voltage is present by using a DVM or equivalent measuring device.

c. Disconnect all leads between the magnet and the Shim Coil Power Supply (P2, P2-W, Heater Cable).

9. Close the Shim Lead Nupro Vent Valve.

NOTICE

Make sure the cap is replaced and does NOT leak, which could result in gaseous helium loss or frosting.

10. Retract the Shim Lead in conformance with Shim Lead Engagement and Disengagement, tighten the brass cap and check for leaks.

8.5 Finalization

1. Make sure the shimming results are available to other personnel for future shimming:

   a. Copy all `.map`, `.cur` and `.shm` files generated during shimming to a CD.

   b. Copy the `.map`, `.cur` and `.shm` files to the console.

   c. Record the directory path of files copied to the console in the Shim Process Log of theChapter 8, Shimming Process Data.

   d. Leave the CD on site with this Magnet and Cryogens Subsystem manual.

2. Put the magnet back in normal condition in conformance with Preparations for Field Measurement and the appropriate Service Methods documentation.

   NOTE: For Field Adjustments after Shimming, refer to Field Adjustment after Shimming.
   For Magnetic Field Stability Checks, refer to Chapter 4, Field Stability Check.

9 Polarity and Functional Checks

9.1 Personnel Requirements

Personnel Requirements	Preliminary Reqs	Procedure	Finalization
2	Included in 'Procedure'	As Required	Included in 'Procedure'

9.2 Overview

Follow the procedures below if problems are encountered in shimming a W-Series LCC300 magnet with the Superconducting Shim Coils. These procedures will help to identify a Shim Cable wiring error, a Shim Coil switch malfunction, a Switch Heater malfunction or a defective/misaligned Shim Coil. If problems are encountered, refer to Chapter 6, Magnet System Wiring, Chapter 6, RuO Circuits and Pinouts and Chapter 4, Magnet Electrical Checks for troubleshooting assistance.

9.3 Preliminary Requirements

9.3.1 Tools and Test Equipment

Item	Qty	Effectivity	Part#	Manufacturer
3.0T Warning Sign & Label Kit	1	-	2379494	-
Portable Oxygen Monitor	1	-	2287000	-
Cryogen Safety Wear Kit; one kit per person	1	-	46-271137G1	-
Nonabsorbent protective clothing (long sleeve shirt and pants); one set per person	1	-	-	-
Nonferrous Safety Shoes; one pair per person	1	-	-	-
MetroLab Teslameter Kit	1	-	46-251865G4	-
#6 MetroLab Probe (included in MetroLab Teslameter Kit 46-251865G4)	1	-	2295525-5	-
LCC300 Field Mapping Fixture (included in LCC300 Passive Shimming Kit 2386029)	1	-	2380758	-
Shim Power Supply	1	-	46-260777G3	-

Item	Qty	Effectivity	Part#	Manufacturer
Field Shim Cable Kit (if not already ordered with the magnet)	1	-	2135558	-
Service Methods documentation for the magnet/enclosures (available through the Common Document Library at gehealthcare.com or through your local GE Healthcare Service Representative)	1	-	-	-

9.3.2 Required Conditions

Condition	Reference	Effectivity
The removal of some magnet enclosure components may be required to complete the Polarity and Functional Checks procedure. Refer to Chapter 5, Upper and Side Enclosure Removal (Wide Open enclosures) or to Chapter 5, Introduction to HDe & HDx Enclosures*and* the appropriate Service Methods documentation (available through the Common Document Library at gehealthcare.com or through you local GE Healthcare Service Representative) before continuing with the Polarity and Functional Checks procedure if cover removal is required.	Chapter 5, Upper and Side Enclosure Removal	-
(continue)	Chapter 5, Introduction to HDe & HDx Enclosures	-

9.4 Procedure

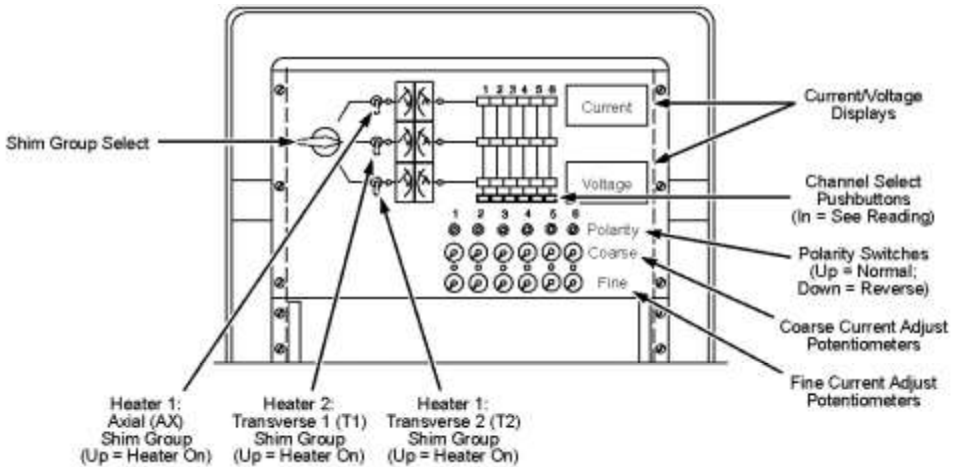
9.4.1 Axial Correction Coil Checks

1. Connect the Superconducting Shim Power Supply and cable in conformance with the 'Preparations for Shimming' subsection of Shimming.

2. Setup LCC300 Field Mapping Fixture 2380758 with its Single Probe Mounting Board, a Teslameter and a #6 Probe in conformance with the 'Preparation for Field Mapping' and 'Teslameter Adustment and Resynchronization' subsections of Preparations for Field Measurement.

3. Turn on all Switch Heaters for 5 minutes, then turn the heaters off to produce a virgin magnetic field. See Illustration 3-148.

Illustration 3-148: Shim Power Supply Controls (Front Panel)



4. Verify that the #6 Teslameter Probe is at the physical center of the magnet (radius = 0 cm, axial = 0 cm and 0 degree rotation). Adjust Probe position radially, angularly and axially as needed in conformance with Preparations for Field Measurement.

5. Record the virgin magnetic field at the magnet center (Z = 0 cm) in Table 3-20.

Table 3-20: Axial Coil Data

S/C Coil	Gauss Reading (XX,XXX.X)		
	Z = -10 cm (Patient End)	Z = 0 cm	Z = +10 cm (Service End)
Virgin Map			
Axial 1			
Axial 2			
Axial 3			
Axial 4			
Axial 5*			
Axial 6*			
* WB-series LCC300 magnets only.			

6. Move the Probe along the Z-axis and record the virgin magnetic field at Z = -10 cm (-3.94 in.) and at Z = +10 cm (+3.94 in.).

⚠WARNING

POTENTIAL MAGNET QUENCH
ACTIVATING THE MAIN SWITCH HEATER WHILE THE MAGNET IS AT FIELD WILL RESULT IN A QUENCH.
DO NOT TURN ON THE MAIN MAGNET SWITCH HEATER WHILE THE MAGNET IS AT FIELD.

7. Turn on the Axial and Transverse Switch Heaters. Allow the heaters to warm up for 5 minutes.
8. Set the Axial 1 Shim Coil Power Supply to 10 amps, thereby applying 10 amps to the Axial 1 Coil.
9. Turn off the Axial and Transverse S/C Switch Heaters and allow the heaters to cool for 5 minutes.
10. Ramp the Axial 1 Shim Coil Power Supply down to 0 amps.
11. Position the Probe at Z = -10 cm (-3.94 in.), Z = 0 cm and Z = +10 cm (+3.94 in.), recording the measured gauss value at each location in Table 3-20.
12. Subtract value found in Step 11 from the corresponding point in the virgin map measured in Step 5. Compare these “Gauss Differences” with the Axial 1 coil map in Illustration 3-149.

    NOTE: If the polarity is correct for the Axial 1 Coil, the gauss value at the Patient End (Z = -10 cm) will be approximately 180 gauss less than the -10 cm virgin map value. However, the gauss value at the Service end (Z = +10 cm) will be approximately 180 gauss greater than the +10 cm virgin value.

13. Repeat Step 7 through Step 12 for each of the other Axial S/C Coils. Compare the gauss differences for:
    - Axial 1 and 2 of W-series LCC300 magnets with the plots in Illustration 3-149,
    - Axial 3 and 4 of W-series LCC300 magnets with Illustration 3-150,
    - Axial 1 and 2 of WB-series LCC300 magnets with Illustration 3-151,
    - Axial 3 and 4 of WB-series LCC300 magnets with Illustration 3-152
    - Axial 5 and 6 of WB-series LCC300 magnets with Illustration 3-153.

Illustration 3-149: W-Series LCC300 Magnet Axial 1 and Axial 2 Correction Coil Plots (Normal Polarity & Positive Shim Currents)

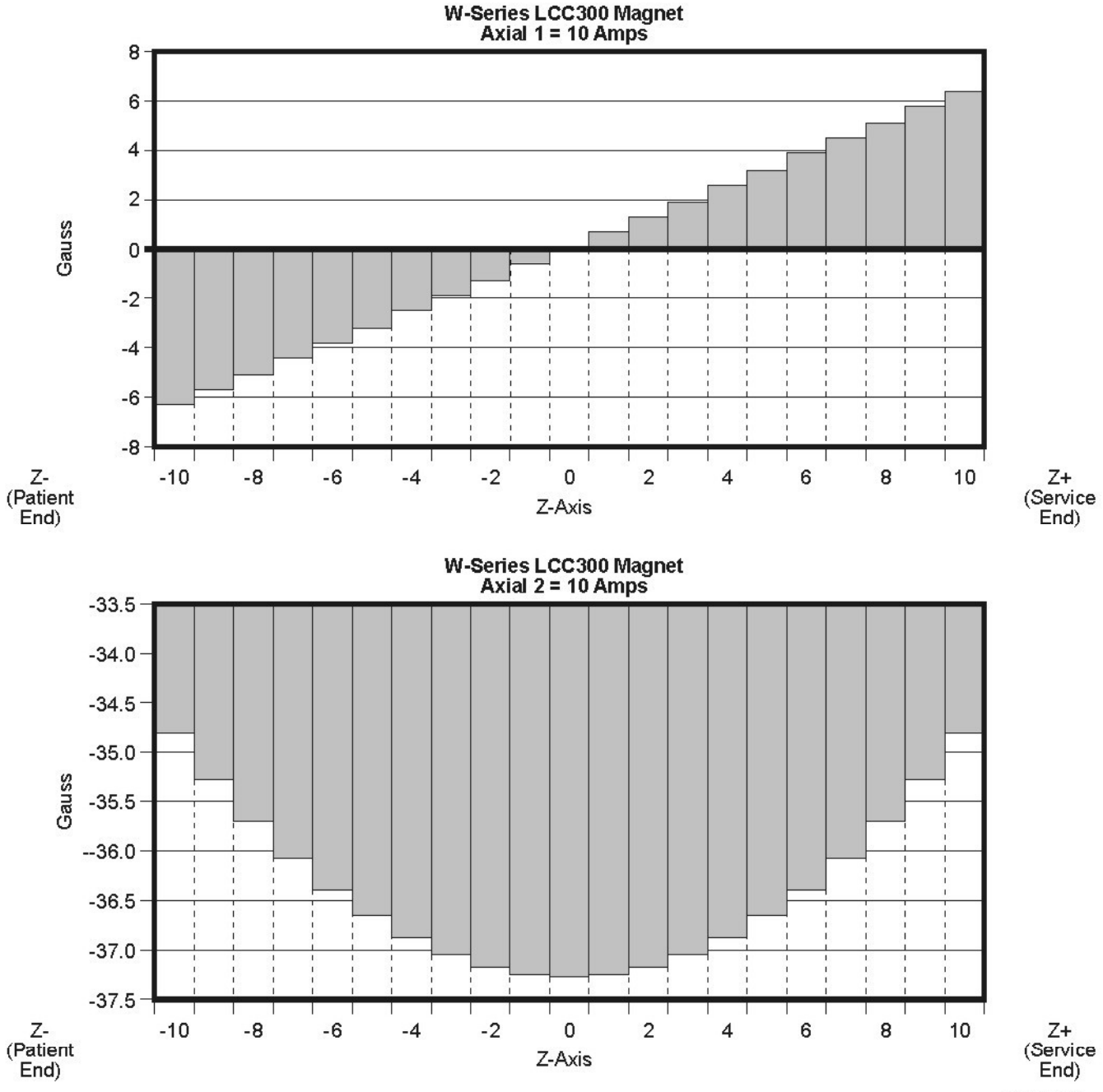


Illustration 3-150: W-Series LCC300 Magnet Axial 3 and Axial 4 Correction Coil Plots (Normal Polarity & Positive Shim Currents)

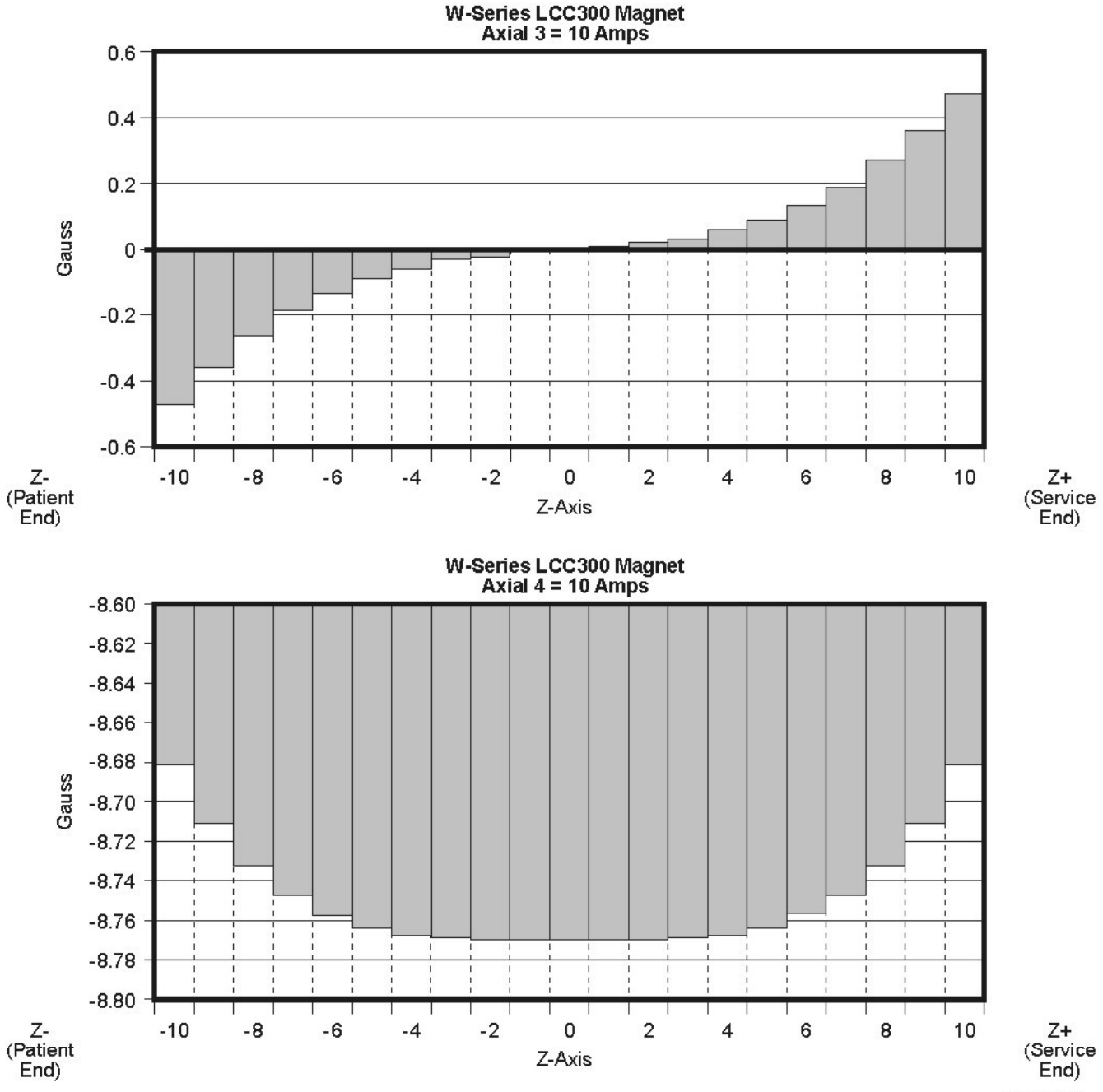


Illustration 3-151: WB-Series LCC300 Magnet Axial 1 and Axial 2 Correction Coil Plots (Normal Polarity & Positive Shim Currents)

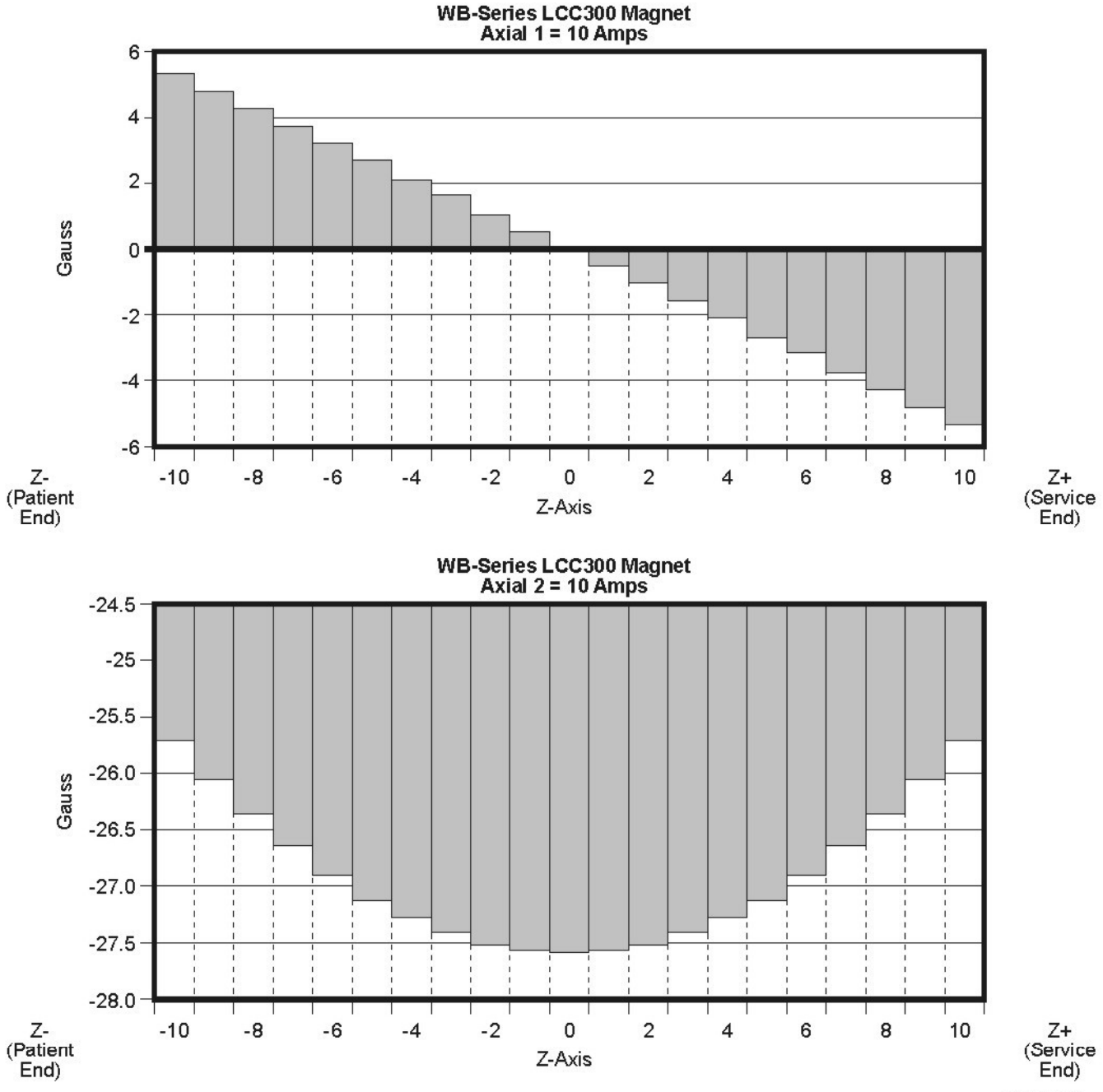


Illustration 3-152: WB-Series LCC300 Magnet Axial 3 and Axial 4 Correction Coil Plots (Normal Polarity & Positive Shim Currents)

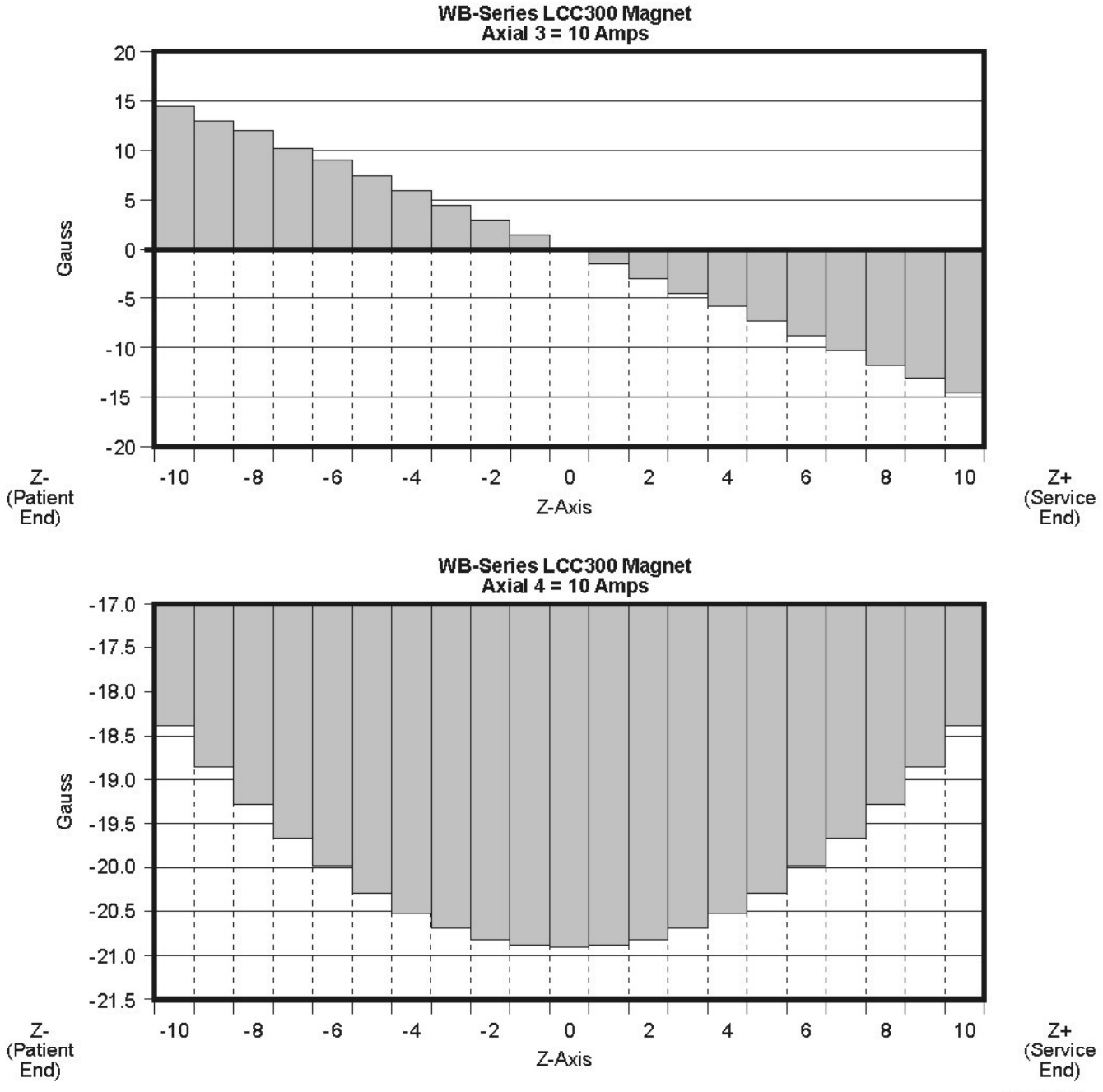
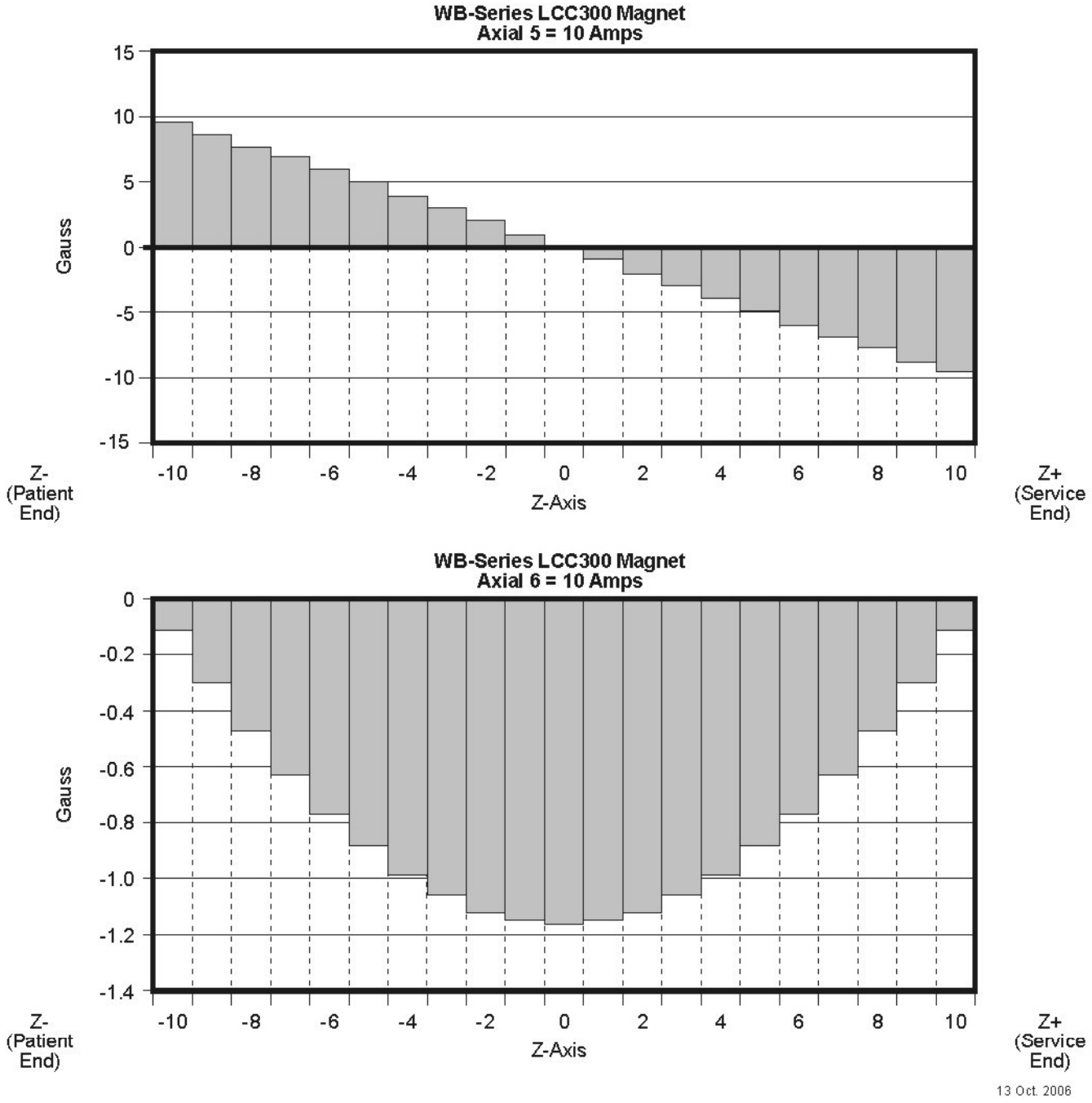


Illustration 3-153: WB-Series LCC300 Magnet Axial 5 and Axial 6 Correction Coil Plots (Normal Polarity & Positive Shim Currents)

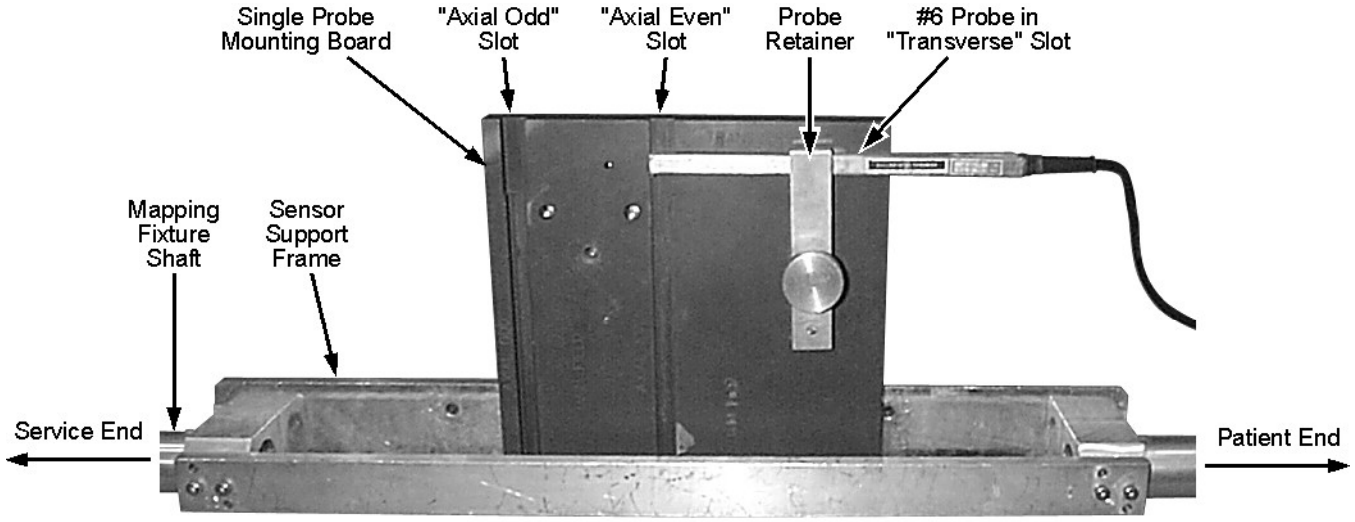


9.4.2 Transverse Correction Coil Checks

1. After completing Section 9.4.1, Axial Correction Coil Checks, dump any remaining current in the Correction Coils by turning on both the Axial and Transverse Switch Heaters for one minute. See Illustration 3-148.

2. Position the #6 Probe in the groove on the LCC300 Field Mapping Fixture's Single Probe Mounting Board marked “Transverse” with the Probe's sensor against the wall of the groove marked “Axial Even” as in Illustration 3-154.

Illustration 3-154: Probe Set-Up for Single Probe Transverse Coil Measurement



3. Measure and record in Table 3-21 a new “Virgin (0 Amps)” magnetic field map as follows:

   a. Position the Probe axially at Z = -10 cm (-3.94 in.).

   b. Rotate the Probe to 0°, 45°, 90°, 135°, 180°, 225°, 270° and 315° angular positions, recording in Table 3-21 the “Virgin (0 Amps)” magnetic field reading at each angular position.

   c. Repeat Step 3.a and Step 3.b with the Probe repositioned first to Z = 0 cm and then repositioned to Z = +10 cm (+3.94 in.).

Table 3-21: Transverse Coil Data

Correction Coil Configuration		Z-Axis	Gauss Reading (XX,XXX.X) with Probe at 15 cm Radius							
Map	Power Supply Current Input(s)		0°	45°	90°	135°	180°	225°	270°	315°
VIRGIN	Virgin (0 Amps)	+10 cm								
		0 cm								
		-10 cm								
T1-1	T1-1 = 10 Amps	+10 cm								
		0 cm								
		-10 cm								
T1-2	T1-2 = 10 Amps	+10 cm								
		0 cm								
		-10 cm								

Correction Coil Configuration		Z-Axis	Gauss Reading (XX,XXX.X) with Probe at 15 cm Radius							
Map	Power Supply Current Input(s)		0°	45°	90°	135°	180°	225°	270°	315°
T1-3	T1-3 = 10 Amps	+10 cm								
		0 cm								
		-10 cm								
T1-4	T1-4 = 10 Amps	+10 cm								
		0 cm								
		-10 cm								
T1-5	T1-5 = 10 Amps	+10 cm								
		0 cm								
		-10 cm								
T1-6*	T1-6* = 10 Amps	+10 cm								
		0 cm								
		-10 cm								
T2-1	T2-1 = 10 Amps	+10 cm								
		0 cm								
		-10 cm								
T2-2	T2-2 = 10 Maps	+10 cm								
		0 cm								
		-10 cm								
T2-3	T2-2 = 10 Amps	+10 cm								
		0 cm								
		-10 cm								
T2-4	T2-4 = 10 Amps	+10 cm								
		0 cm								
		-10 cm								
T2-5	T2-5 = 10 Amps	+10 cm								
		0 cm								
		-10 cm								
T2-6*	T2-6* = 10 Amps	+10 cm								
		0 cm								
		-10 cm								
* WB-series LCC300 magnets only.										

4. Turn on the Transverse and Axial Switch Heaters. Allow the heaters to warm for 2 minutes.

5. Measure and record in Table 3-21 all available T1 and T2 “Correction Coil Configuration” maps (W-series: T1-1 - T1-5 and T2-1 - T2-5; WB-series: T1-1 - T1-6 and T2-1 - T2-6) as follows:

    a. Ramp the correct power supply to the current specified in Table 3-21 for the map.

b. Turn off the Axial and Transverse Odd and Even Switch Heaters. Allow the heaters to cool 2 minutes.

c. Ramp down each power supply mentioned for the map to 0 amps.

d. Position the Probe axially at Z = -10 cm (-3.94 in.).

e. Rotate the Probe to 0°, 45°, 90°, 135°, 180°, 225°, 270° and 315° angular positions, recording in Table 3-21 the map's magnetic field reading at each angular position.

f. Repeat Step 5.d and Step 5.e with the Probe repositioned first to Z = 0 cm and then repositioned to Z = +10 cm (+3.94 in.).

g. Subtract the corresponding “Virgin (0 Amps)” magnetic field value from each data point. With W-series LCC300 magnets compare these “Gauss Differences” with Illustration 3-155 - Illustration 3-160, and with WB-series LCC300 magnets compare them with Illustration 3-161 - Illustration 3-166.

NOTE: The lead connections for any individual coil could be interchanged (mirrored) with another coil. See Illustration 3-167 for determining where wiring problems could occur.

h. Turn on both the Axial and Transverse Switch Heaters. Allow the heaters to warm up for 5 minutes.

i. Repeat Step 5.a - Step 5.h for the next “Correction Coil Configuration.”

Illustration 3-155: W-Series LCC300 Magnet T1-1 and T1-2 Transverse Correction Coil Plots (Normal Polarity & Positive Shim Currents)

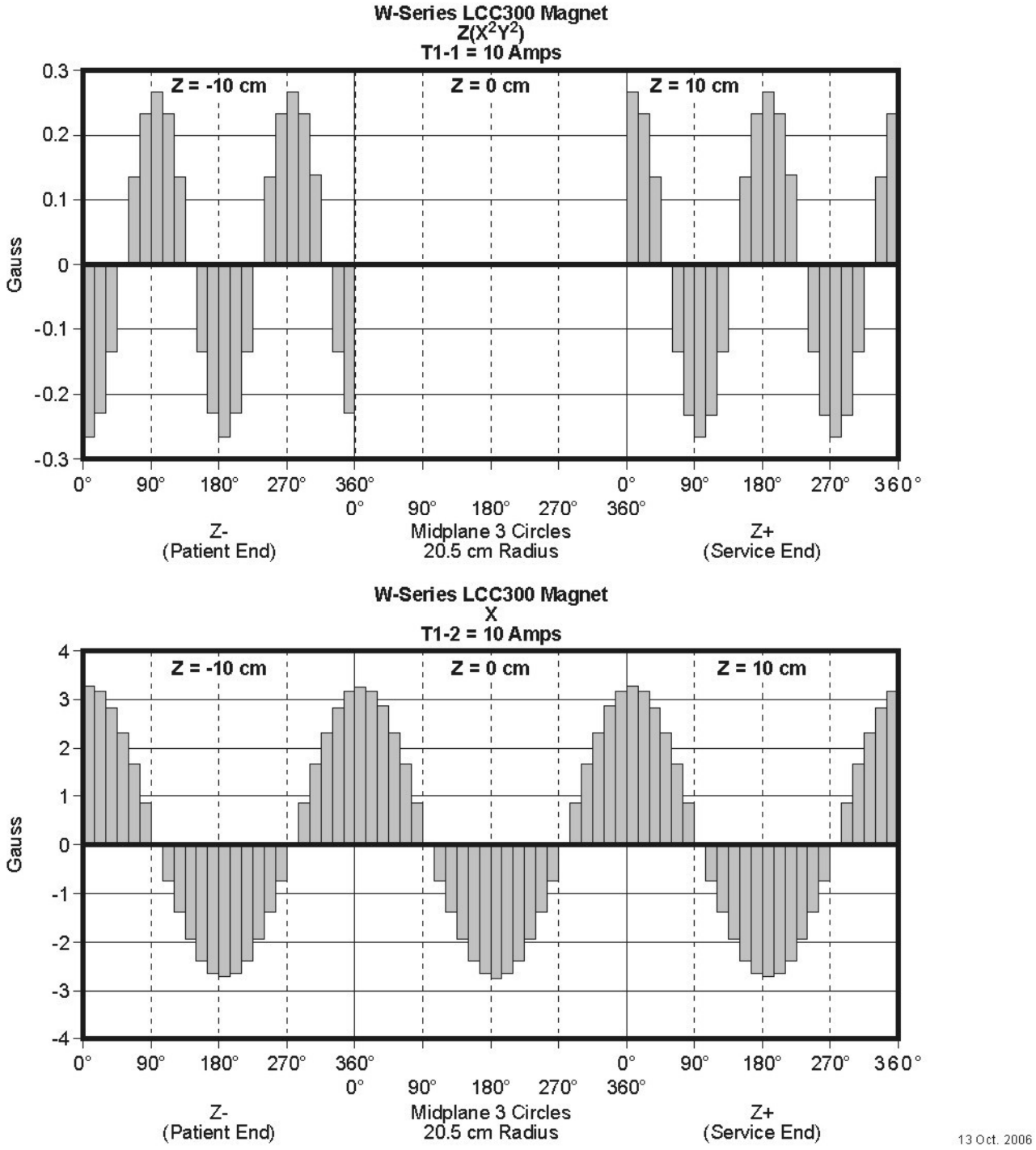


Illustration 3-156: W-Series LCC300 Magnet T1-3 and T1-4 Transverse Correction Coil Plots (Normal Polarity & Positive Shim Currents)

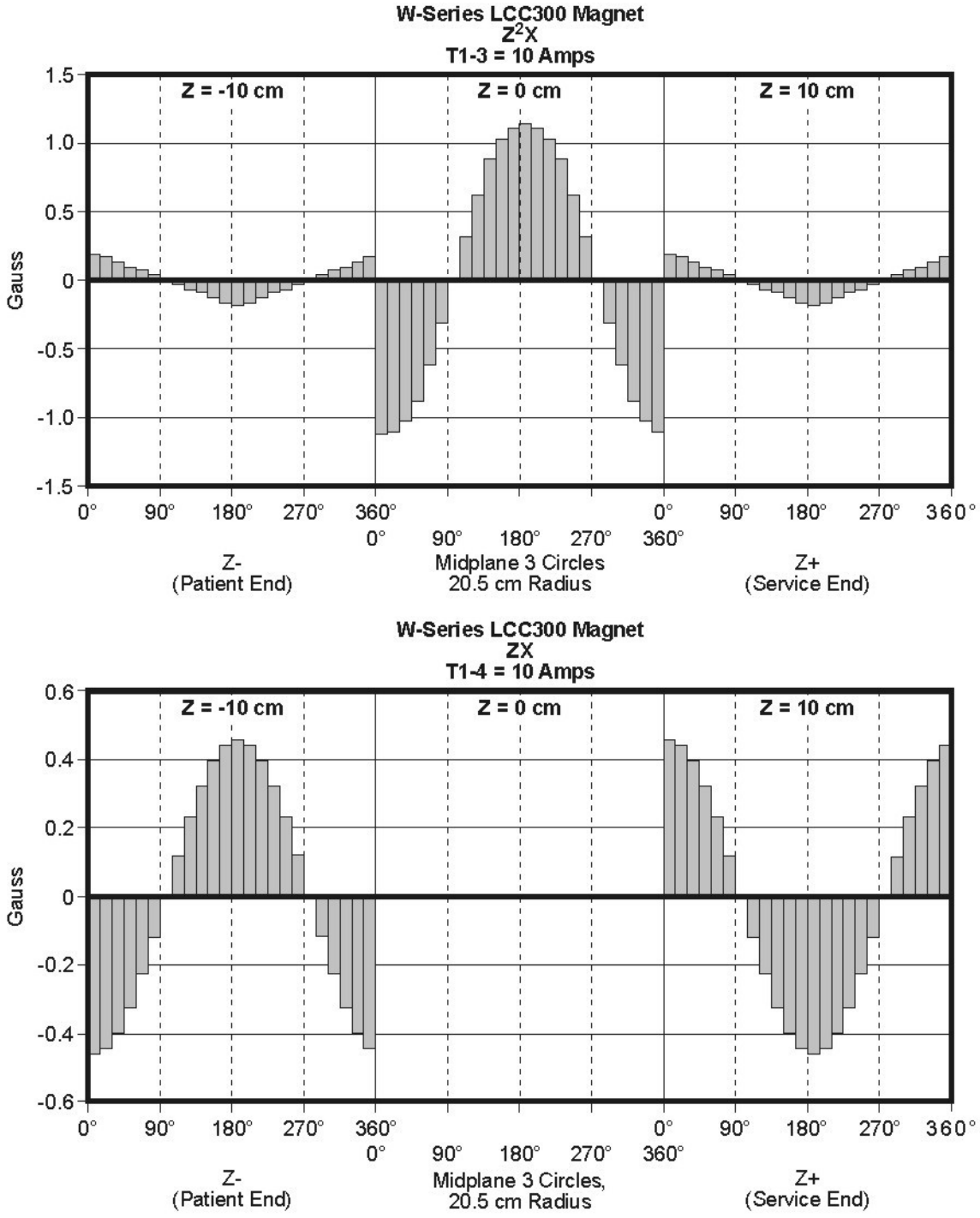


Illustration 3-157: W-Series LCC300 Magnet T1-5 Transverse Correction Coil Plot (Normal Polarity & Positive Shim Currents)

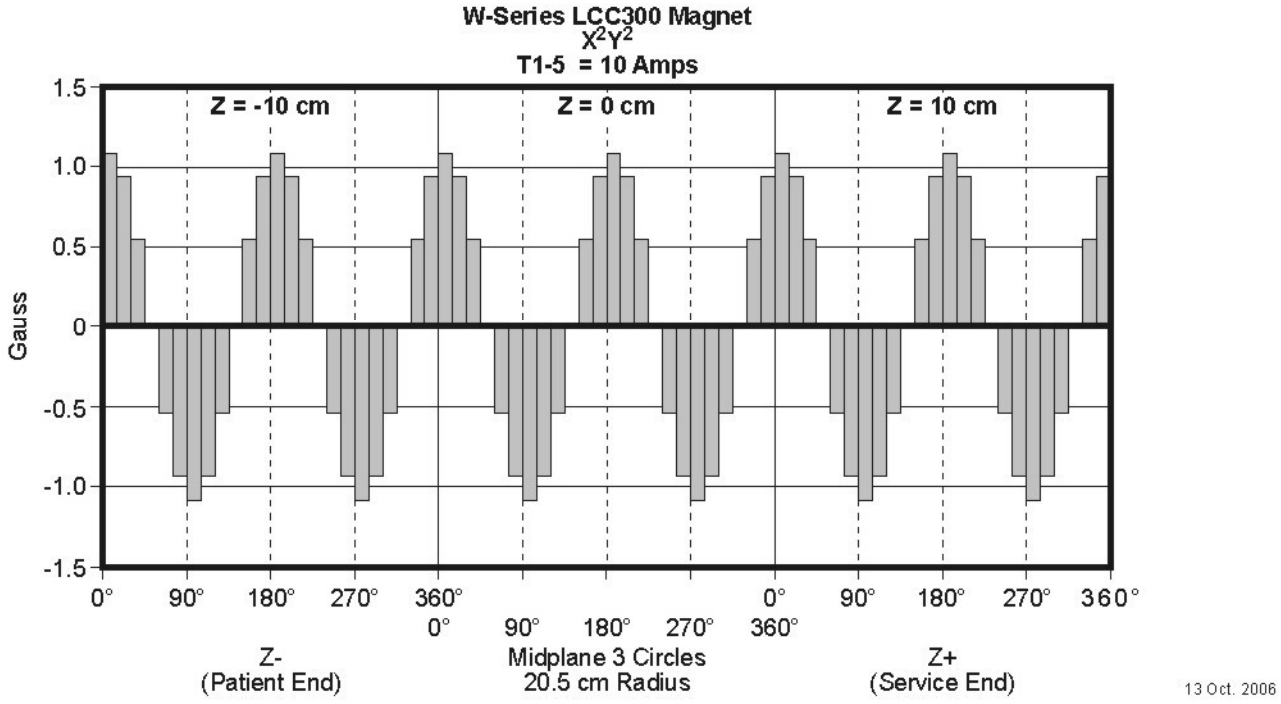


Illustration 3-158: W-Series LCC300 Magnet T2-1 and T2-2 Transverse Correction Coil Plots (Normal Polarity & Positive Shim Currents)

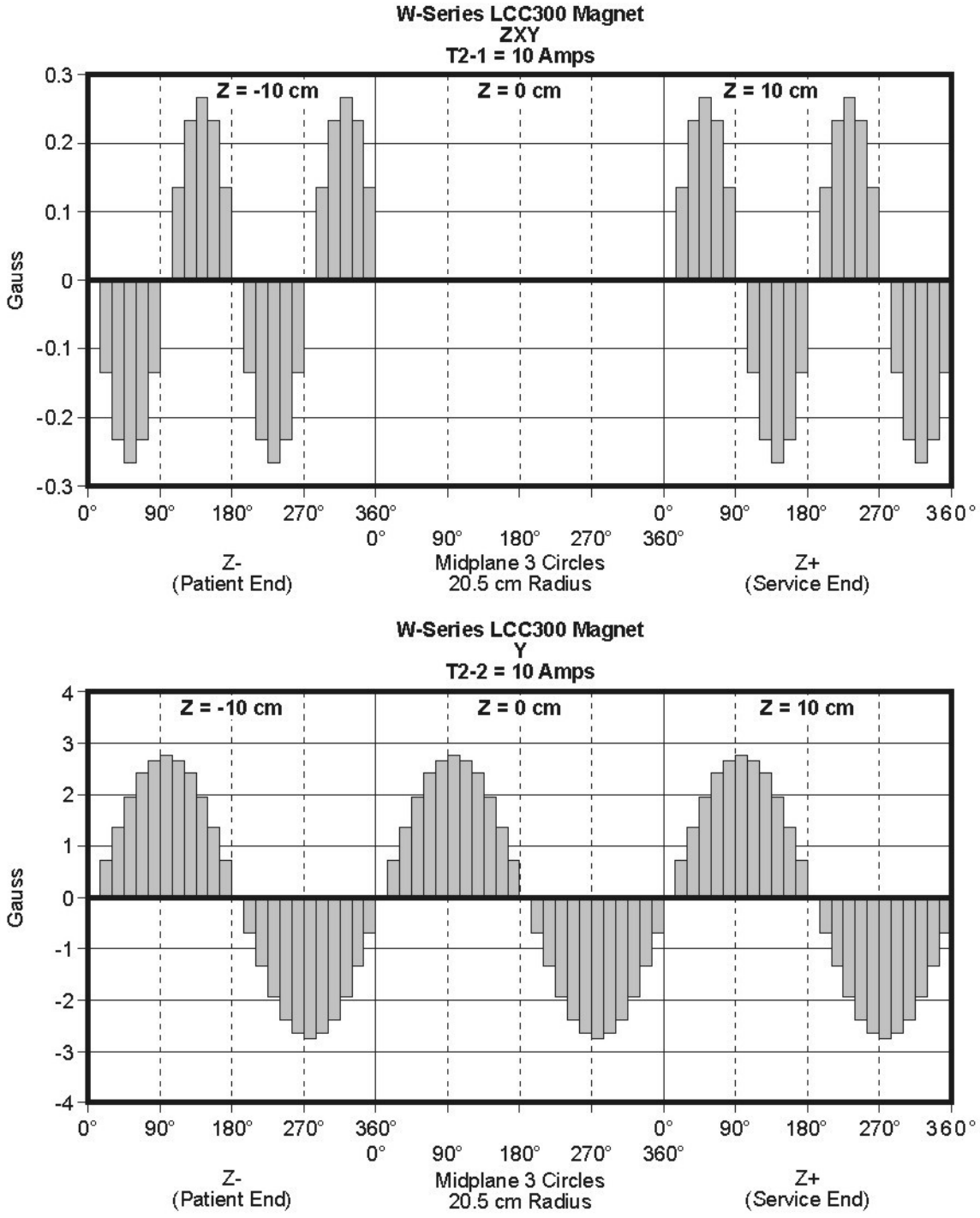


Illustration 3-159: W-Series LCC300 Magnet T2-3 and T2-4 Transverse Correction Coil Plots (Normal Polarity & Positive Shim Currents)

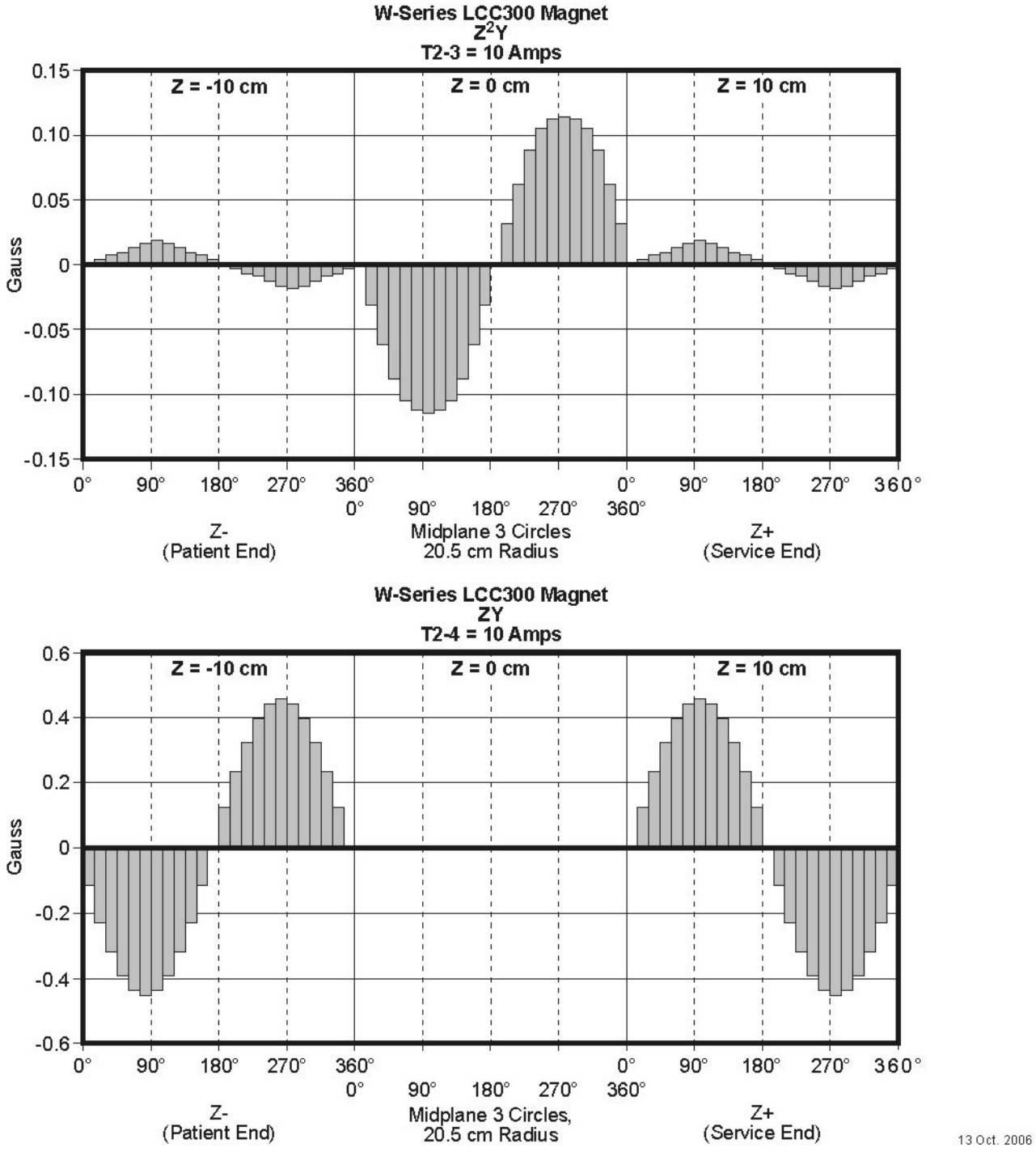


Illustration 3-160: W-Series LCC300 Magnet T2-5 Transverse Correction Coil Plot (Normal Polarity & Positive Shim Currents)

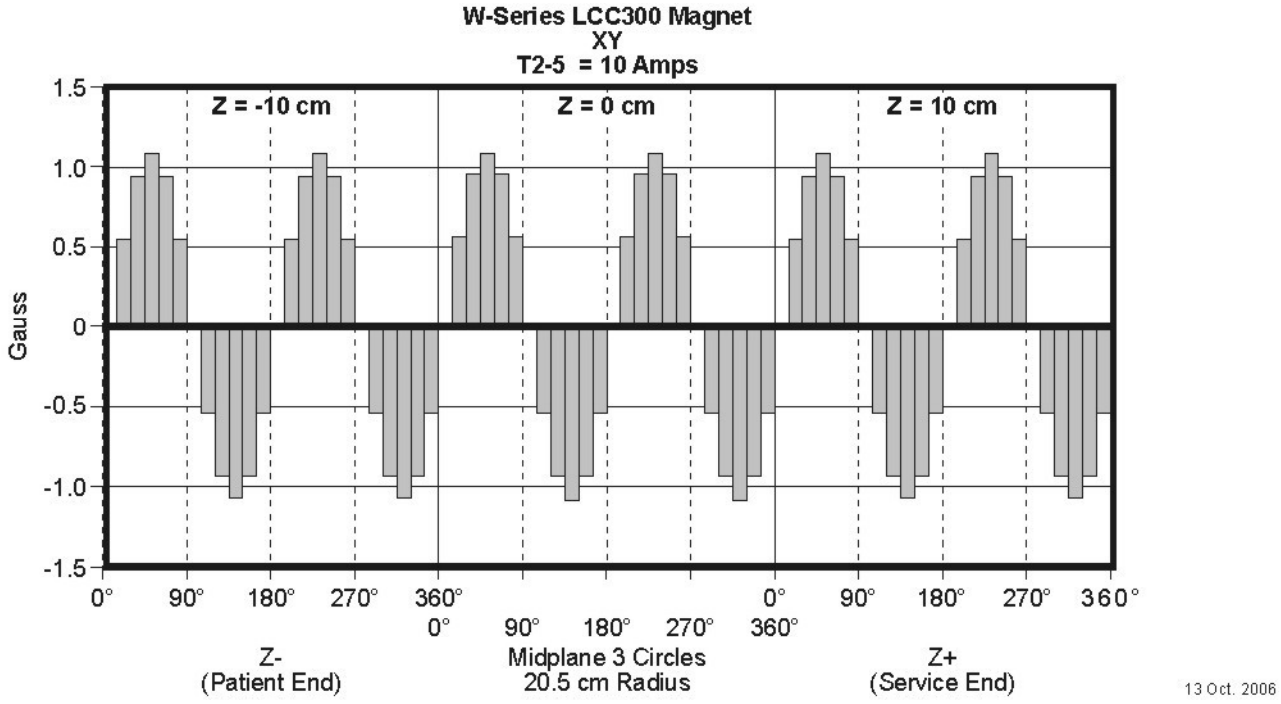


Illustration 3-161: WB-Series LCC300 Magnet T1-1 and T1-2 Transverse Correction Coil Plots (Normal Polarity & Positive Shim Currents)

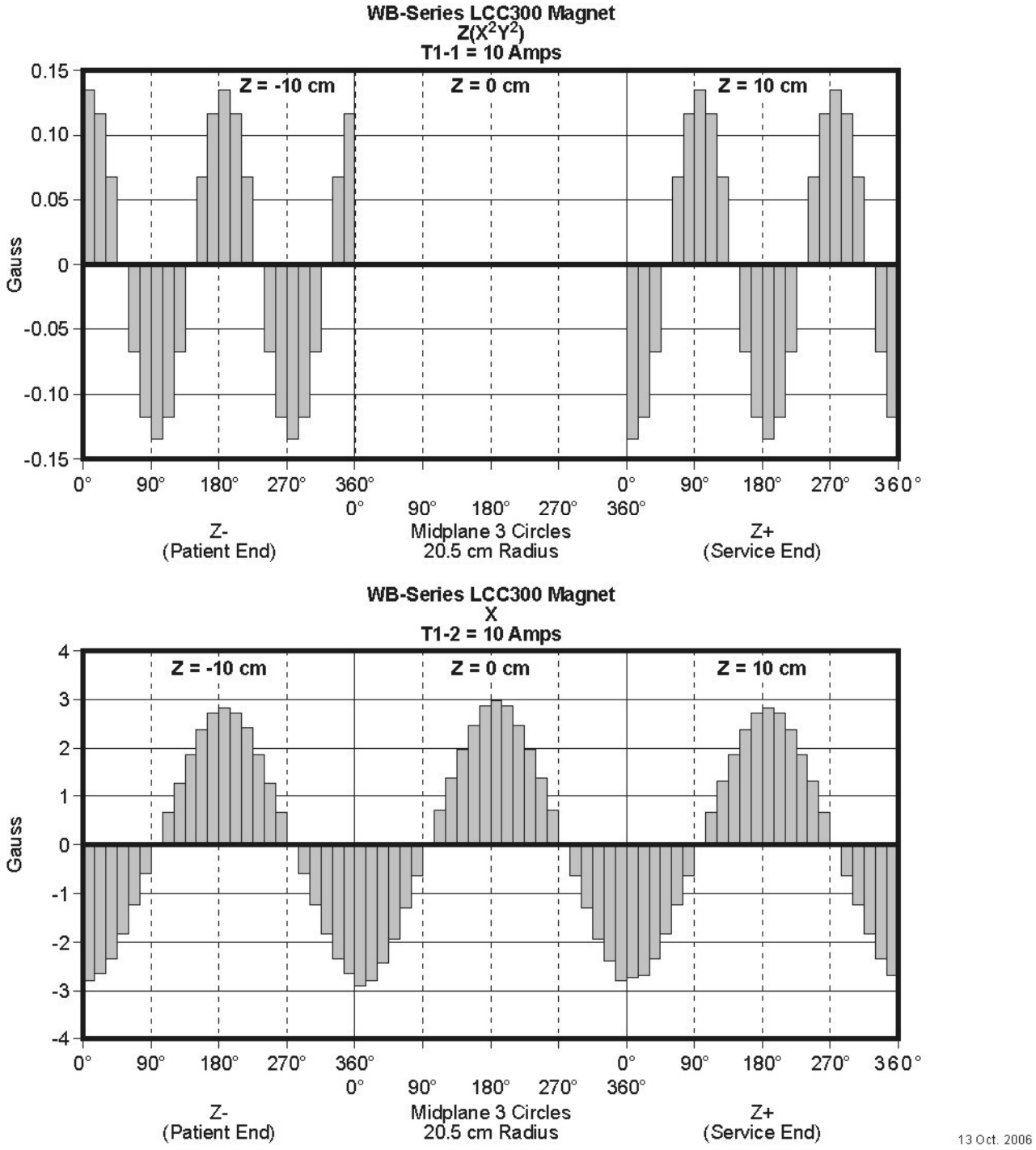


Illustration 3-162: WB-Series LCC300 Magnet T1-3 and T1-4 Transverse Correction Coil Plots (Normal Polarity & Positive Shim Currents)

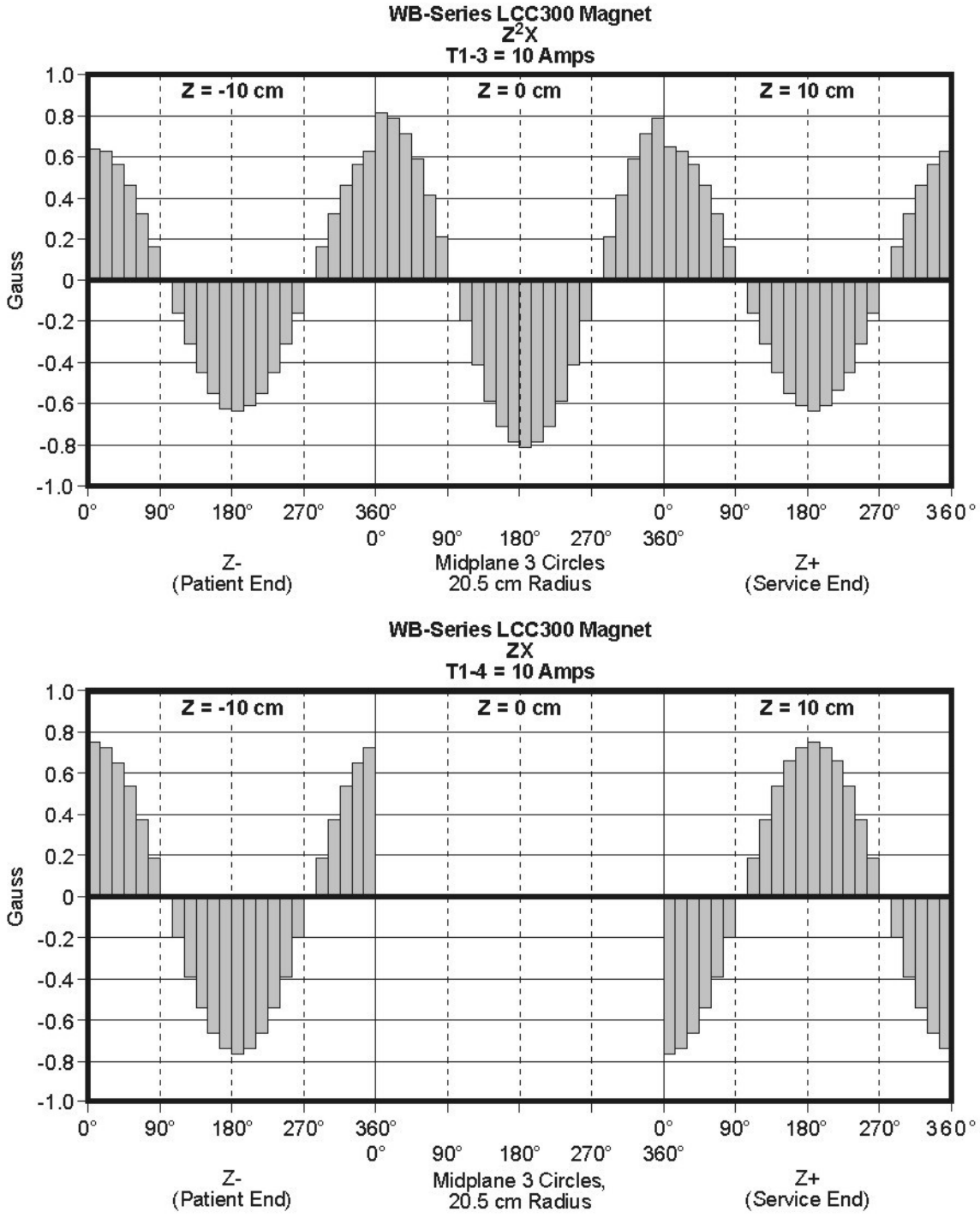


Illustration 3-163: WB-Series LCC300 Magnet T1-5 and T1-6 Transverse Correction Coil Plots (Normal Polarity & Positive Shim Currents)

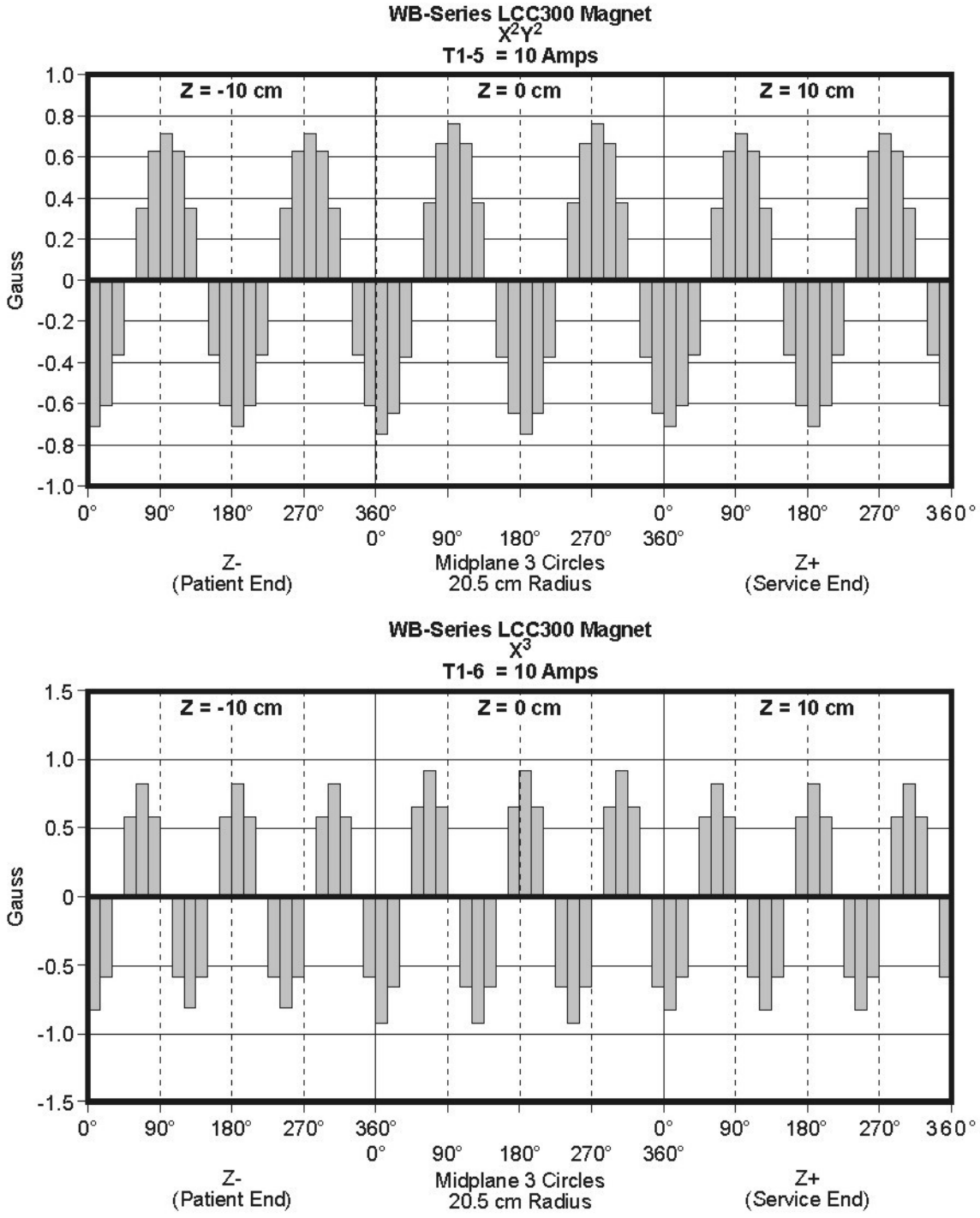


Illustration 3-164: WB-Series LCC300 Magnet T2-1 and T2-2 Transverse Correction Coil Plots (Normal Polarity & Positive Shim Currents)

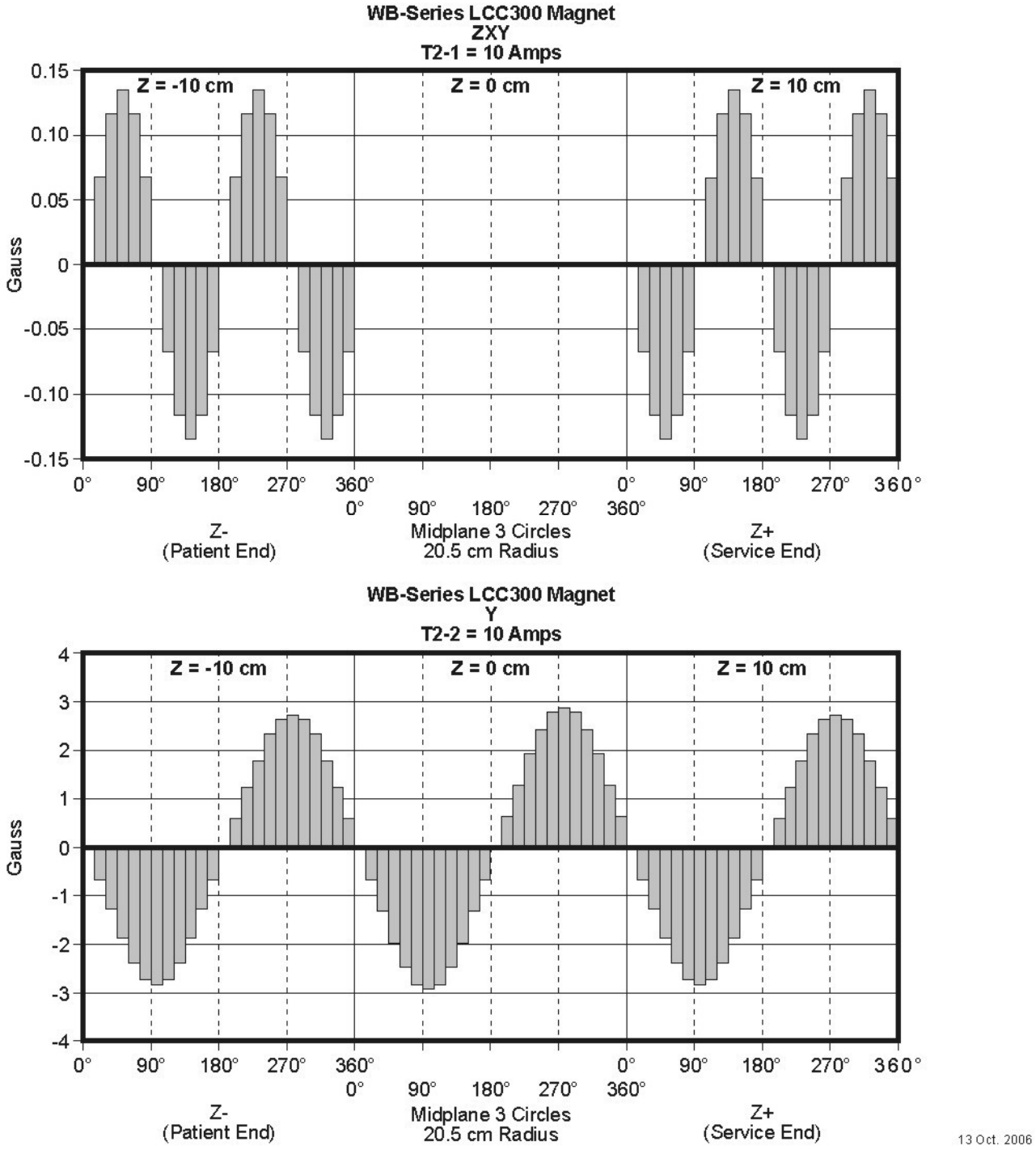


Illustration 3-165: WB-Series LCC300 Magnet T2-3 and T2-4 Transverse Correction Coil Plots (Normal Polarity & Positive Shim Currents)

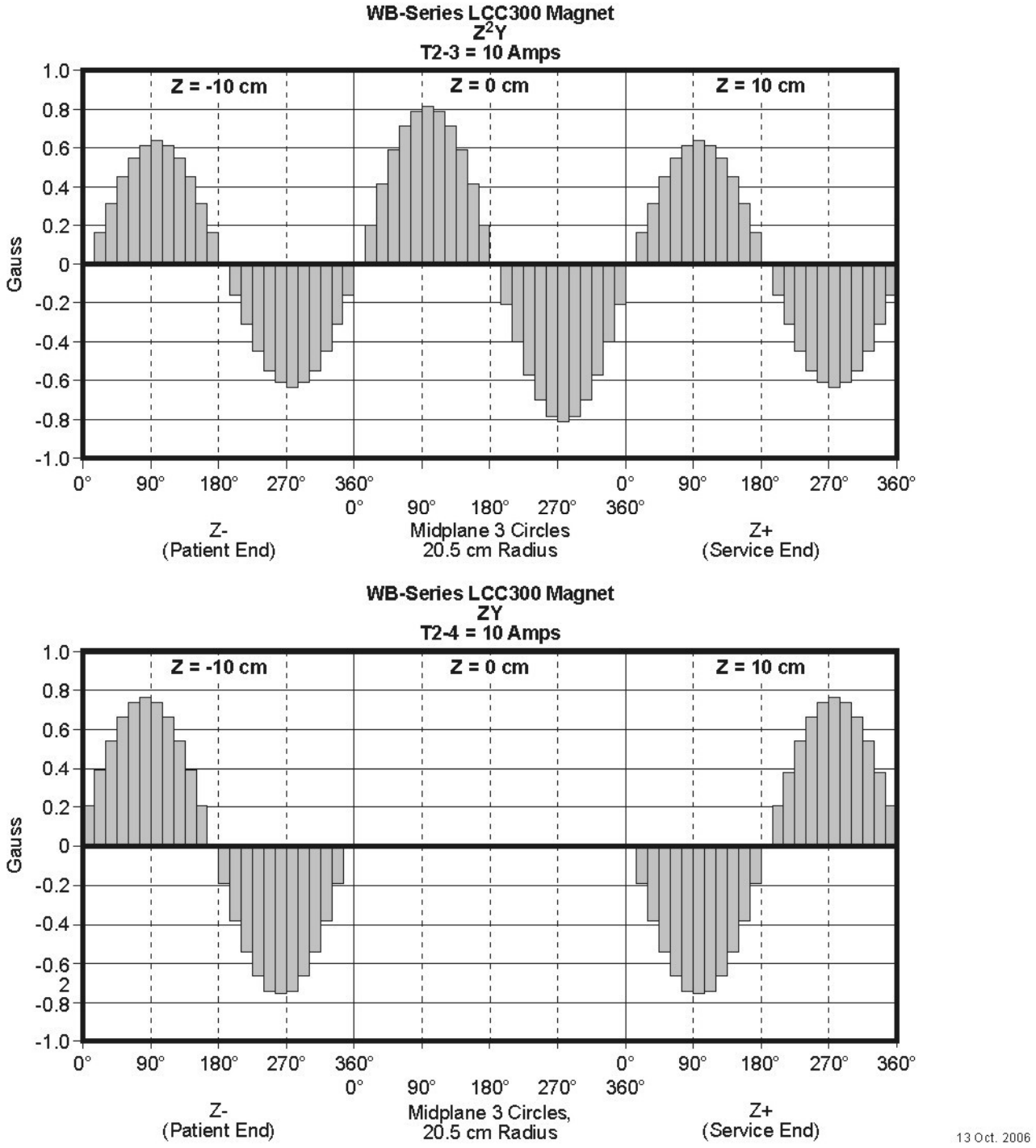


Illustration 3-166: WB-Series LCC300 Magnet T2-5 and T2-6 Transverse Correction Coil Plots (Normal Polarity & Positive Shim Currents)

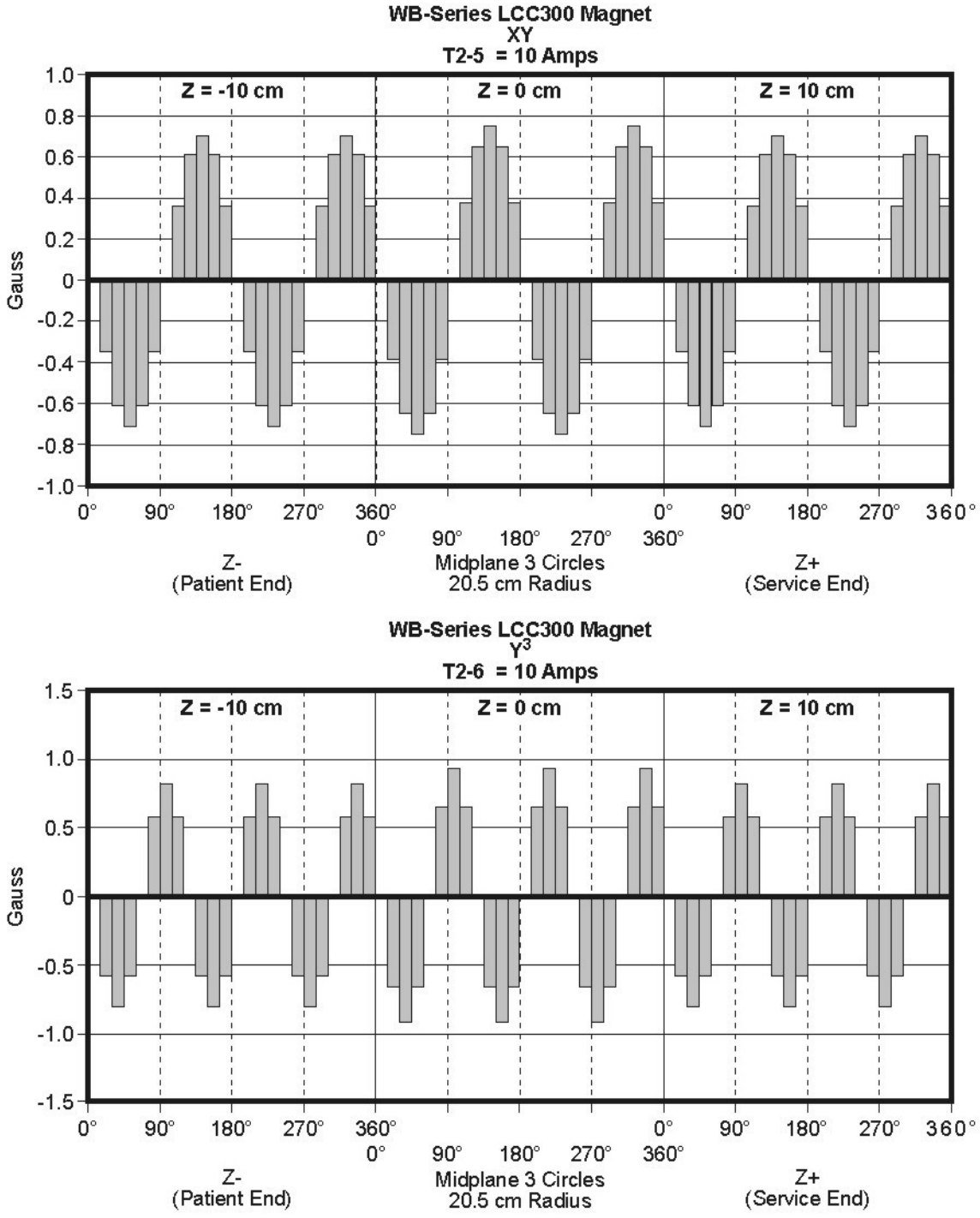
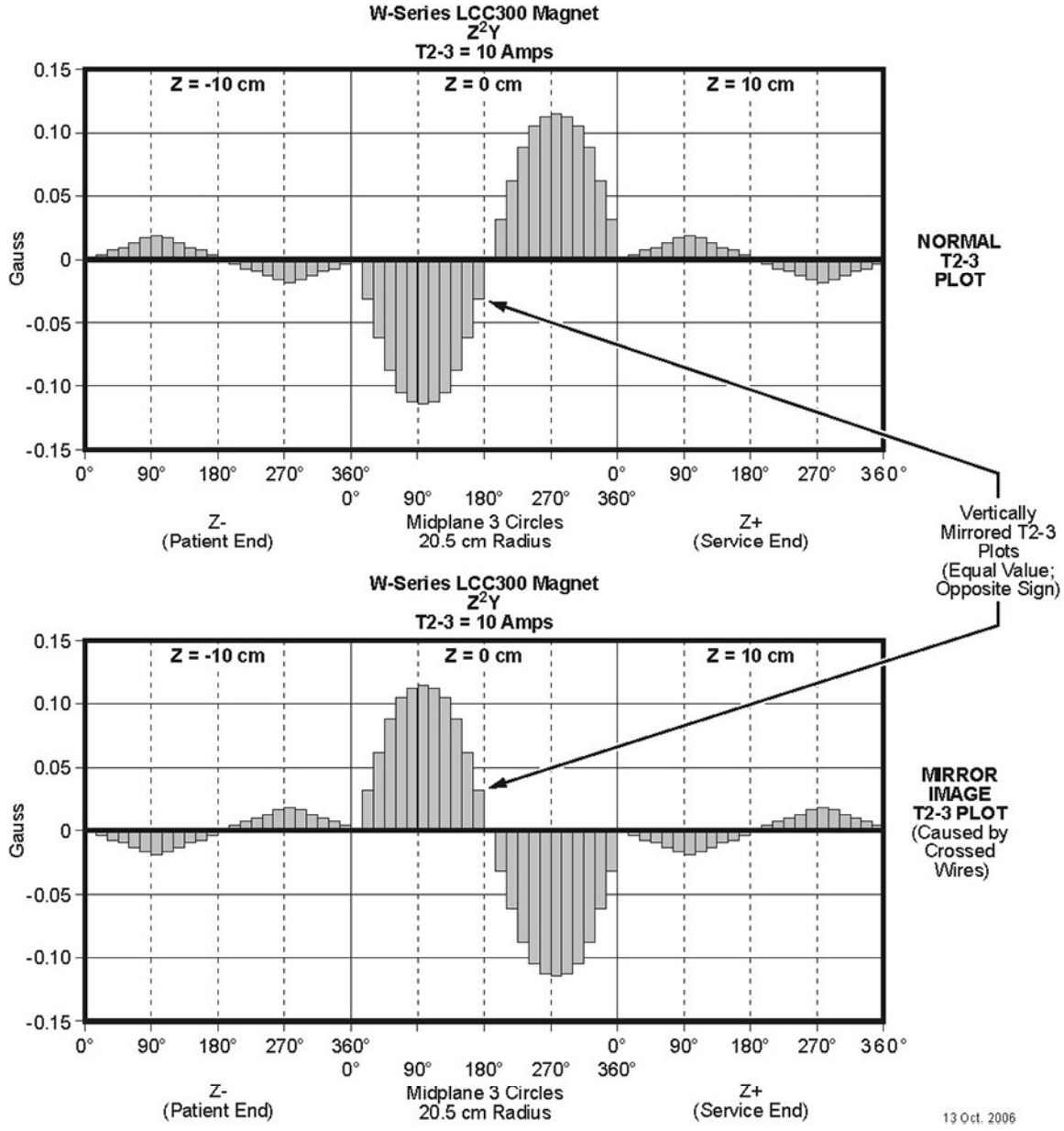


Illustration 3-167: Correction Coil Wiring Problems: Crossed Wires (W-Series LCC300 Example Shown)



9.5 Finalization

No finalization steps.

10 Field Adjustment after Shimming

10.1 Personnel Requirements

Personnel Requirements	Preliminary Reqs	Procedure	Finalization
2	Included in Procedure	4 hours	Included in Procedure

10.2 Overview

The operational field strength for a MR750 Magnet is 30,000 gauss, ±26.0 gauss (127.72 MHz, ±110 kHz). If the magnetic field is out of range after performing LVShim, field adjustment is required.

10.3 Preliminary Requirements

10.3.1 Tools and Test Equipment

Item	Qty	Effectivity	Part#	Manufacturer
3.0T Warning Sign & Label Kit	1	-	2379494	-
Portable Oxygen Monitor	1/ person	-	2287000	-
Cryogen Safety Wear Kit	1 kit/ person	-	46-271137G1	-
Nonabsorbent Protective Clothing (long sleeve shirt and pants)	1 set/ person	-	-	-
Nonferrous Safety Shoes	1 pr./ person	-	-	-
Brass Master Padlock with Brass Shackle	1	-	46-194427P320	-
Brass Master Transition Padlock	1	-	2387081	-
Black & White on Red Lockout Tag	1 pkg. of 25	-	46-194427P322	-
Transition LOTO Tag	1	-	46-194427P313	-

Item	Qty	Effectivity	Part#	Manufacturer
Line Cord Plug Cover, Plugs ≤3 in. wide by ≤ 5.875 in. long (76 mm by 149 mm), Cords ≤1.25 in. (31 mm) diameter	1	-	46-194427P321	-
750 Amp TCR 7.5T750 Main Power Supply 46-260776G3 or 1,000 Amp ESS 7.5-1000-2-D-1236 Main Power Supply 46-260776G4		-	46-260776G3 or 46-260776G4	-
Shim Power Supply	1	-	46-260777G3	-
750 Amp Ramp Cable Kit 2135435 or 1,000 Amp Ramp Cable Kit with Ground 2353394	1	-	2135435 or 2353394	-
Shim Cable Kit (if not already ordered with the magnet)	1	-	2135558	-
MetroLab Teslameter Kit	1 kit	-	46-251865G4	-
No. 6 MetroLab Probe (included in MetroLab Teslameter Kit 46-251865G4)	1	-	2295525-5	-
Digital Voltmeter (DVM)	1	-	-	-
Ammeter	1	-	-	-
Titanium Tool Kit: Basic Set 5113258, Installation Set 5112581, or other nonferromagnetic tools (magnets with magnetic fields >1.5T)	1	-	5113258 or 5112581	-
HDx Service Platform - Can use Universal Service Ladder/Platform 2319156 if service space ≥30 in. (762 mm)	1	-	5155291 or 2319156	-
Cardboard Box or nonferromagnetic frame	1	-	-	-

Item	Qty	Effectivity	Part#	Manufacturer
Service Methods documentation for the magnet/enclosures (available through the Common Documentation Library at www.gehealthcare.com or your local GE Healthcare Service Representative)	1	-	-	-

10.3.2 Safety

DANGER

POTENTIAL FATAL INJURY!
BEFORE AND WHILE PERFORMING THE FIELD ADJUSTMENT AFTER SHIMMING PROCEDURE:

- **MAKE SURE TO REVIEW AND FULLY UNDERSTAND ALL SUPERCONDUCTING (S/C) MAGNET PORTIONS OF, AND**
- **MAKE SURE TO FULLY COMPLY WITH ALL REQUIRED ITEMS FOR THE FIELD ADJUSTMENT AFTER SHIMMING PROCEDURE IN THE MAGNET & CRYOGEN SERVICE SAFETY REQUIREMENTS SUBSECTION OF CHAPTER 1, 2301164PRE MR MAGNET SAFETY REQUIREMENTS.**

DANGER

POTENTIAL FATAL INJURY!
BEFORE STARTING THE FIELD ADJUSTMENT AFTER SHIMMING PROCEDURE:
HAVE ALL WORK ASSISTANTS OR OBSERVERS COMPLY WITH THE BUDDY SYSTEM REQUIREMENTS & CERTIFICATION SUBSECTION OF "2301164PRE MR MAGNET SAFETY REQUIREMENTS."

WARNING

ASPHYXIATION HAZARD!
THE FIELD ADJUSTMENT AFTER SHIMMING PROCEDURE GENERATES ODORLESS, COLORLESS HELIUM GAS THAT DISPLACES OXYGEN IN THE AIR.
MAKE SURE MAGNET ROOM VENT EXHAUST FAN IS ON BEFORE STARTING THE FIELD ADJUSTMENT AFTER SHIMMING PROCEDURE.

⚠WARNING

POTENTIAL QUENCH HAZARD!
THE MAGNET MAY QUENCH, RAPIDLY RELEASING CRYOGENIC GASES, IF ITS LIQUID HELIUM LEVEL DROPS TOO LOW DURING THE FIELD ADJUSTMENT AFTER SHIMMING PROCEDURE.
MAKE SURE THE MAGNET ≥90% FULL OF LIQUID HELIUM BEFORE STARTING THE FIELD ADJUSTMENT AFTER SHIMMING PROCEDURE.

⚠WARNING

POTENTIAL QUENCH HAZARD!
APPLYING POWER THROUGH THE SHIM LEAD BEFORE THE SHIM LEAD IS SUFFICIENTLY COOLED OR WHILE THE SHIM LEAD'S VENT VALVE IS CLOSED MAY RESULT IN A MAGNET QUENCH.
MAKE SURE THE SHIM LEAD'S NUPRO VENT VALVE IS OPEN AND FROSTING IS VISIBLE ON THE SHIM LEAD HOUSING BEFORE TURNING ON THE SHIM COIL POWER SUPPLY.

⚠WARNING

ELECTRICAL SHOCK HAZARD!
CONNECTING THE MAIN LEAD EXTENSIONS WHILE THE MAIN POWER SUPPLY IS ON WILL CREATE A RAPID ELECTRICAL DISCHARGE OF 100 VOLTS OR MORE.
MAKE SURE INPUT POWER TO THE MAIN POWER SUPPLY IS DISCONNECTED WHEN CONNECTING THE MAIN LEAD EXTENSIONS.

⚠WARNING

ELECTRICAL SHOCK HAZARD!
TOUCHING BOTH MAIN LEAD EXTENSIONS AT THE SAME TIME OR ALLOWING THEM TO CONTACT EACH OTHER WHILE THE MAGNET IS AT FIELD WILL RESULT IN A RAPID DISCHARGE THROUGH THEIR CONTACT POINTS IF THE SWITCH HEATER IS ACTIVATED OR CIRCUIT RESISTANCE DEVELOPS AT THAT MOMENT.
DO NOT TOUCH BOTH MAIN LEAD EXTENSIONS AT THE SAME TIME. DO NOT ALLOW THE MAIN LEAD EXTENSIONS TO CONTACT EACH OTHER.

⚠WARNING

POTENTIAL COLD BURN HAZARD!
EXPOSURE TO CRYOGENS AND CONTACT WITH COLD OBJECTS IS POSSIBLE DURING THE FIELD ADJUSTMENT AFTER SHIMMING PROCEDURE.
WEAR PROTECTIVE CLOTHING, NONABSORBENT GLOVES AND GOGGLES WHEN PERFORMING THE FIELD ADJUSTMENT AFTER SHIMMING PROCEDURE.

⚠WARNING
ELECTRICAL SHOCK HAZARD!
CONTACT WITH CONNECTORS LEADING TO AN ENERGIZED POWER SUPPLY CAN CAUSE ELECTRICAL SHOCK.
FOLLOW CHAPTER 1, OSHA LOCKOUT/TAGOUT (LOTO) PROCEDURES WHILE MAKING ELECTRICAL CONNECTIONS TO A MAIN POWER SUPPLY OR A SHIM POWER SUPPLY. SEE .

10.3.3 Required Conditions

Condition	Reference	Effectivity
Make sure the area is secure and that ALL required Warning Signs are posted to meet the safety requirements stated in the following document before starting the Field Adjustment after Shimming procedure.	Chapter 1, 2301164PRE MR Magnet Safety Requirements	-
Removal of some magnet enclosure components may be required to complete the Field Adjustment after Shimming procedure. Refer to the appropriate document that follows **and** to the Service Methods documentation (available through the Common Documentation Library at www.gehealthcare.com or your local GE Healthcare Service Representative) before continuing if cover removal is required.	Chapter 5, Upper and Side Wide-Open Enclosure Removal	-
(continued)	Chapter 5, Introduction to HDe & HDx Enclosures	-
Make sure the Shim Power Supply is calibrated in conformance with the vendor manual (46-294439P7) and that the heater currents are set to Transverse 1 = 610 mA, ±5 mA, Transverse 2 = 610 mA, ±5 mA and Axial = 710 mA, ±10 mA.	-	-
Make sure the liquid helium level is ≥90% before starting the Field Adjustment after Shimming procedure.	Liquid Helium Fill	-
The Shim Lead must be engaged, precooled and frosted in conformance with the following document before entering shim currents.	Shim Lead Engagement and Disengagement	-

Condition	Reference	Effectivity
Make sure the Magnet Room exhaust fan is on and operational and the Magnet Room door is propped open before starting the Field Adjustment after Shimming procedure.	-	-

10.4 Procedure

10.4.1 Removing Transverse and Axial Shim Currents

1. Top fill the magnet to >90% helium level in conformance with Liquid Helium Fill before continuing with the Field Adjustment after Shimming procedure.

2. Replace the Main Lead Extension's Contact Bands in conformance with Chapter 5, Main Lead Extension Contact Band Replacement.

⚠CAUTION

Potential Magnet Quench!
The magnet may quench if the Nupro Valve on the Shim Lead is closed or the Shim Lead is not cold.
Make sure the Nupro Valve is fully open and the valve is frosted before slowly engaging the Shim Lead. Do not remove the Shim Lead's Orifice Cap that controls helium gas flow. Always engage/disengage the Shim Lead in conformance with "Shim Lead Engagement and Disengagement."

3. Make sure the Shim Lead Assembly is engaged in conformance with Shim Lead Engagement and Disengagement.

4. Set up a Teslameter and No. 6 Probe for single point field measurement in conformance with Preparations for Field Measurement and make sure the probe is at the physical center (R = 0, Z = 0) of the magnet.

5. Make sure the Main and Shim Power Supplies are checked and adjusted in conformance with the vendor manuals supplied with each unit.

   NOTE: Refer to the vendor manuals for power supply control locations and descriptions.

6. Make sure the Shim Lead Vent Valve is open and frost is present on the Shim Lead Connector Housing before removing shim currents.

⚠WARNING

ELECTRICAL SHOCK HAZARD!
CONTACT WITH CONNECTORS LEADING TO AN ENERGIZED POWER SUPPLY CAN CAUSE ELECTRICAL SHOCK.
FOLLOW LOTO PROCEDURES WHILE MAKING ELECTRICAL CONNECTIONS TO A MAIN POWER SUPPLY OR A SHIM POWER SUPPLY.

7. Disconnect and LOTO input power to both the Main and Shim Coil Power Supplies. Verify that no voltage is present by using a DVM or equivalent measuring device.

8. Measure the present Base Frequency of the magnet's magnetic field and from this, subtract the desired Center Frequency to calculate the Delta Frequency.

   Base Freqency - Center Frequency = Delta Frequency

   Delta Frequency = _____ Hz

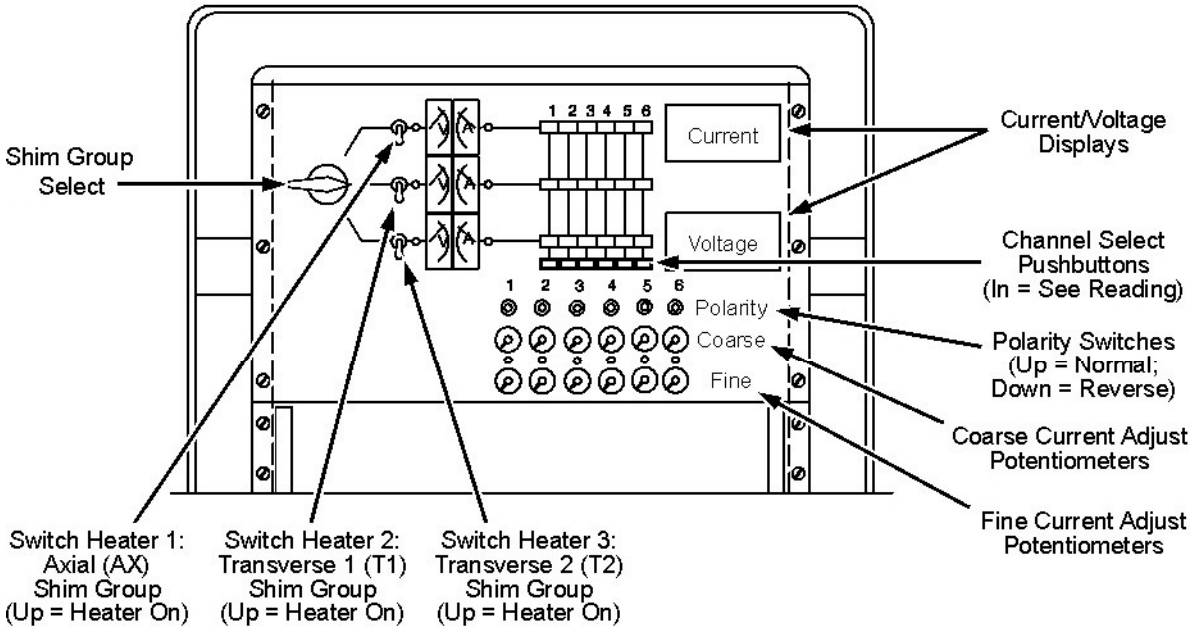
9. Connect the Shim Power Supply to the magnet in conformance to the Shim Coil Power Supply Connections subsection of Shimming.

10. Remove LOTO and connect input power to the Shim Coil Power Supply.

11. Switch on main power to the Shim Power Supply.

12. Set the Shim Group Select Switch to the appropriate group (T1, T2, and Axial). It is recommended that the Transverse Coils be ramped down first, then the Axial Coils.

Illustration 3-168: Shim Power Supply Controls (Front Panel)



13. Dial into the Shim Power Supply all last recorded Shim Currents from Chapter 8, SC Shimming Data. Make sure the shim current polarities are correct.

14. Turn on the appropriate Switch Heater (T1, T2 or Axial) on the Shim Power Supply.

    a. Verify that the heater currents are set to Transverse 1 = 610 mA, ±5 mA; Transverse 2 = 610 mA, ± 5 mA; and Axial = 710 mA, ± 10 mA.

    b. If any current level is not correct, adjust the corresponding T1, T2 or AX Switch Heater Adjustment Screw on the rear of the Shim Power Supply.

15. Allow five (5) minutes for the Switch Heater to drive the switches resistive.
16. Slowly adjust the Current Controls for the appropriate shim group (T1, T2 or Axial) to zero.
17. Turn off the appropriate Switch Heater (T1, T2 or Axial).
18. Repeat Step 12 through Step 17 for the Transverse 2 Coils, then for the Axial Coils.
19. Turn off main power to the Shim Power Supply.
20. Disconnect the heater cable from Shim Power Supply.

⚠WARNING
ELECTRICAL SHOCK HAZARD!
CONTACT WITH CONNECTORS LEADING TO AN ENERGIZED POWER SUPPLY CAN CAUSE ELECTRICAL SHOCK.
FOLLOW LOTO PROCEDURES WHILE MAKING ELECTRICAL CONNECTIONS TO THE SHIM POWER SUPPLY.

21. Disconnect and LOTO input power to the Shim Coil Power Supply. Verify that no voltage is present by using a DVM or equivalent measuring device.

10.4.2 Resistance Checks

⚠WARNING
ELECTRICAL SHOCK HAZARD!
CONTACT WITH CONNECTORS LEADING TO AN ENERGIZED POWER SUPPLY CAN CAUSE ELECTRICAL SHOCK.
FOLLOW LOTO PROCEDURES WHILE MAKING ELECTRICAL CONNECTIONS TO THE MAIN POWER SUPPLY.

1. Disconnect and LOTO input power to the Main Power Supply. Verify that no voltage is present by using a DVM or equivalent measuring device.
2. If resistance checks were not previously performed on the ramping circuit, connect the Main Power Supply and Main Lead Extensions to the magnet in conformance with Connections for Ramping and Shimming.
3. Make sure all power supply Heater Switches are set to off or **O**. (See the two illustrations below.)

Illustration 3-169: 750 Amp TCR 7.5T750 S/C Main Coil Service Power Supply Cabinet

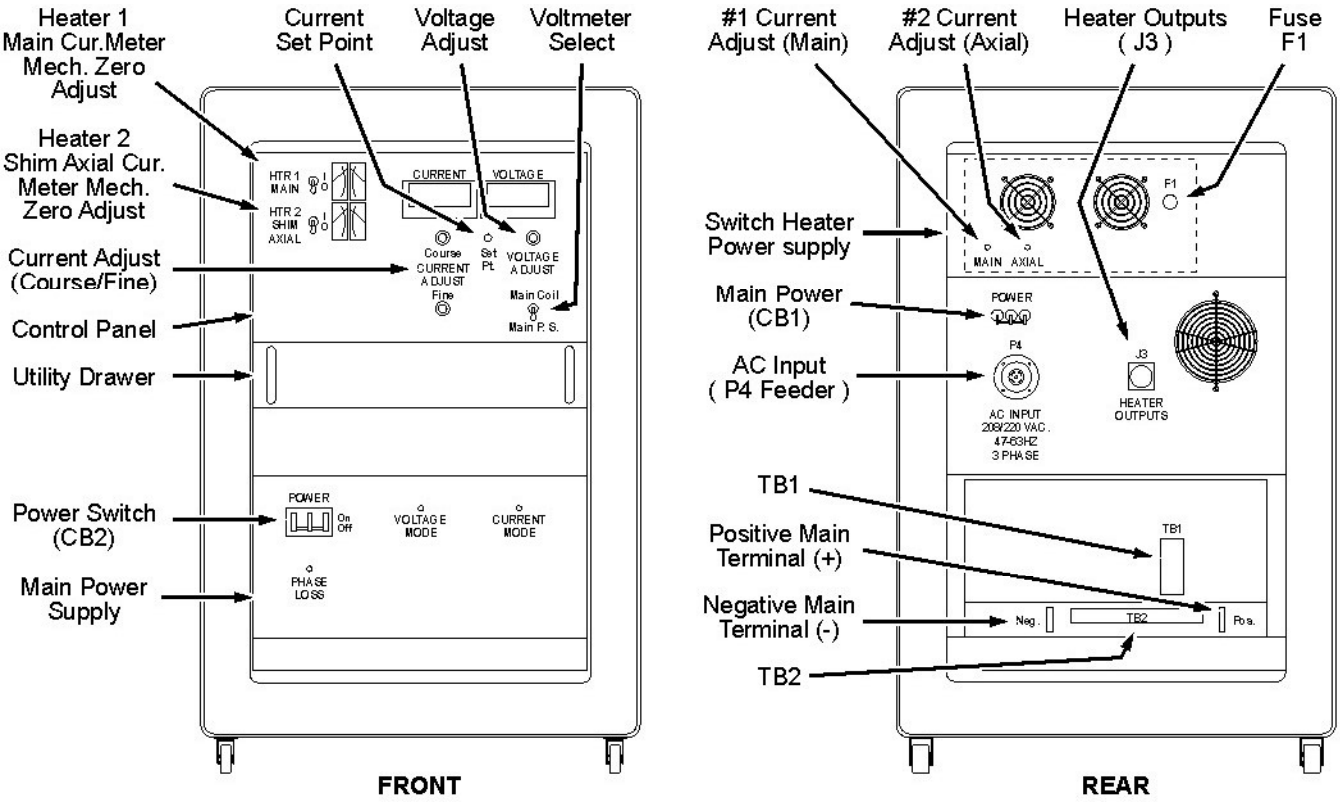
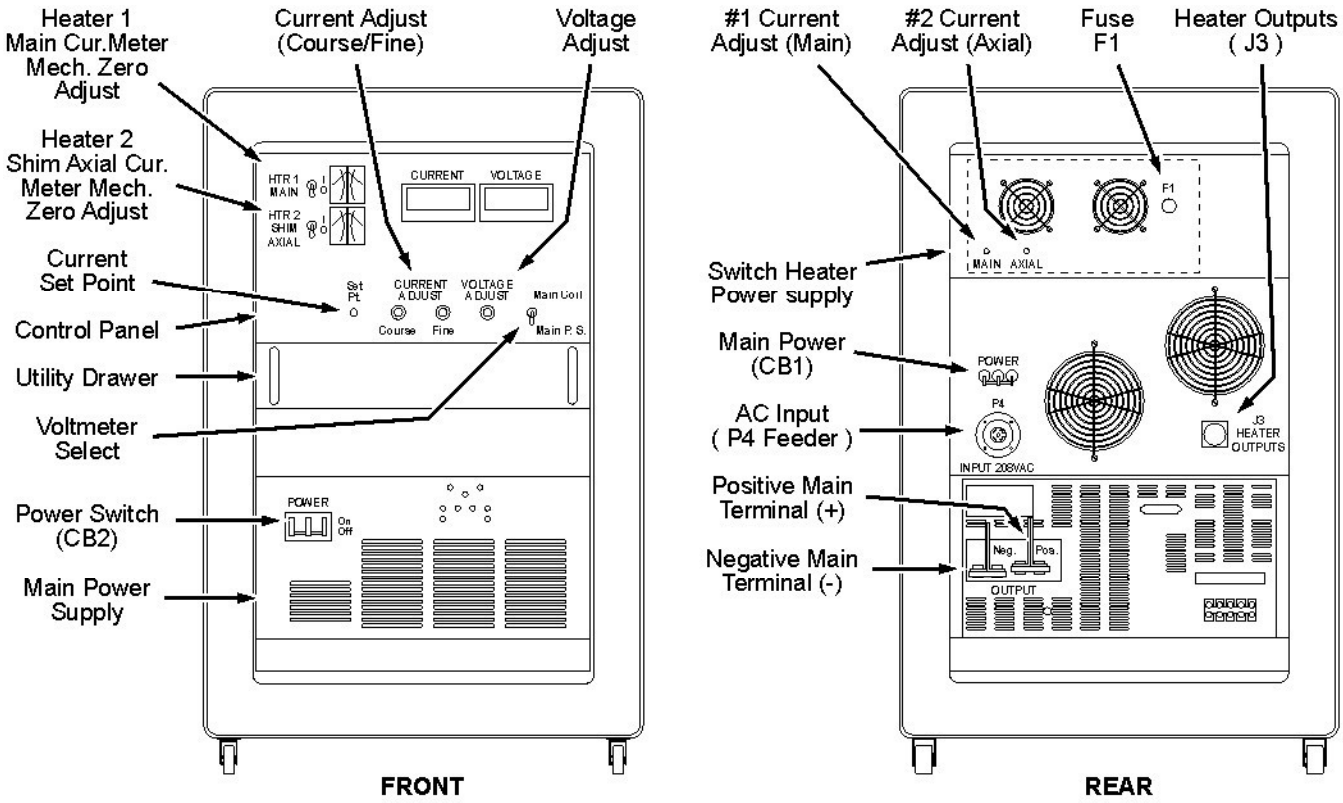


Illustration 3-170: 1,000 Amp ESS7.5-1000-2-D-1236 S/C Main Coil Service Power Supply Cabinet



4. Set the Current and Voltage Adjustment Controls on the Main Power Supply to zero (fully CCW).

5. Remove LOTO and connect input power to the Main Power Supply.

⚠WARNING

POTENTIAL MAGNET QUENCH!
TURNING ON THE MAIN HEATER SWITCH WHILE PERFORMING THESE RESISTANCE CHECKS WILL CAUSE A MAGNET QUENCH.
MAKE SURE THE MAIN HEATER SWITCH STAYS OFF DURING RESISTANCE CHECKS.

6. Turn on the Main Power Supply's Input Power Switches. (There are duplicate Main Power and Power On switches on the front and back of the Main Power Supply.)

7. Make sure the Main Heater Switch is off, then turn on the Axial Shim Heaters.

   a. Observe the current rise in the Main Power Supply Ammeter (710 mA, ±10 mA) to verify circuit continuity.

   b. If the heater current is not correct, adjust it with the Current Adjustment control on the rear of the Power Supply.

8. Connect a Digital Voltmeter (DVM) to the end of the Voltage Sense Leads.
9. Set the power supply Voltmeter Toggle Switch to the MAIN COIL position.
10. Set the Current Adjustment Coarse Control on the power supply to maximum (fully CW).
11. Observe the Main Power Supply's Ammeter, and slowly turn the Voltage Adjustment Control CW to set a 375 amp current through the Main Leads, Main Lead Extensions, and persistent Main Switch.
12. Record the voltage reading on the DVM in Chapter 8, Magnet Ramping and Parking Current Log.

⚠CAUTION
Potential Magnet Quench
Voltage readings >100 millivolts (mV) at 375 amps indicate unacceptable internal contact resistance at the Main Lead Extensions. Higher resistances will add more heat to the magnet, increasing boil-off and possibly causing a quench during ramping.
Make sure the voltage readings are ≤100 mV at 375 Amps.

13. If the DVM voltage is >100 mV, perform one or more of the following to reduce contact resistance:
    a. Wait approximately one minute with current running, readings may drop as the Main Lead Extensions cool.
    b. Tighten the nuts (one flat at a time) on top of the Hold-Down Tool while measuring DVM readings.
    c. If the reading still exceeds 100 mV:
        i. Turn the Voltage and Current Adjustment controls to zero (fully CCW).

⚠WARNING
ELECTRICAL SHOCK HAZARD!
CONTACT WITH CONNECTORS LEADING TO AN ENERGIZED POWER SUPPLY CAN CAUSE ELECTRICAL SHOCK.
FOLLOW LOTO PROCEDURES WHILE MAKING ELECTRICAL CONNECTIONS TO ANY POWER SUPPLY.

        ii. Turn off the Main Power Supply input power, and disconnect and LOTO input power to the Main Power Supply. Verify that no voltage is present by using a DVM or equivalent measuring device.
        iii. Check and tighten the bolts securing the Ramp Cables to the Power Supply and Main Leads Extensions.
        iv. Lift and reseat the Main Leads.

v. Remove LOTO and reconnect input power to the Power Supply.

d. Repeatedly failing the contact resistance check may indicate one of the following:

- Main Lead Extension Contact Bands replaced as directed in Connections for Ramping and Shimming are not performing correctly and need replacing in conformance with Chapter 5, Main Lead Extension Contact Band Replacement.
- Main Leads are damaged and need replacing.

e. If changes are made in the previous step, repeat Step 13.a through Step 13.d.

NOTICE

Do NOT continue to the next step until after the DVM voltage is <100 mV.

14. Set the power supply's Voltmeter Select Switch to the MAIN POWER SUPPLY position so the voltmeter will display the power supply output to the output lugs. If the voltage exceeds 2.2 V at 375 amps during the test, repeat Step 13.

NOTE: A voltage less than 2.2 V at 375 amps indicates acceptable system resistance.

15. Turn the Current and Voltage Adjustment Controls to zero (fully CCW), and continue to the next section.

10.4.3 Main Field Adjustment

⚠WARNING

POTENTIAL QUENCH HAZARD!
INCORRECT CONNECTION POLARITY AND POWER SUPPLY CURRENT SETTINGS CAN CAUSE THE MAGNET'S MAIN COILS TO QUENCH AND CAN BURN UP THE POWER SUPPLY WHEN TURNING ON THE MAIN SWITCH.
MAKE SURE THE CONNECTION POLARITY AND POWER SUPPLY CURRENT SETTINGS ARE THE SAME AS LAST RECORDED IN CHAPTER 8, MAGNET RAMPING AND PARKING CURRENT LOG.

⚠WARNING

POTENTIAL QUENCH HAZARD!
IF THE AXIAL SHIM HEATER SWITCH IS NOT ON DURING THE ENTIRE MAIN FIELD ADJUSTMENT PROCESS, A MAGNET QUENCH CAN OCCUR AND IRREPARABLE DAMAGE SHIM COIL DAMAGE CAN BE DONE. THE POWER SUPPLY WILL NOT PASS CURRENT TO THE MAIN LEAD EXTENSIONS WITH THE AXIAL SHIM HEATER OFF.
MAKE SURE THE AXIAL SHIM HEATER SWITCH REMAINS ON DURING THIS FIELD ADJUSTMENT AFTER SHIMMING PROCEDURE.

⚠WARNING

POTENTIAL QUENCH HAZARD!
THE MAGNET MAY QUENCH IF THE MAIN POWER SUPPLY EXPERIENCES LARGE OUTPUT FLUCTUATIONS AND/OR EXCESSIVE RIPPLE.
MAKE SURE THE MAIN POWER SUPPLY IS ROUTINELY CALIBRATED AT AN APPROVED FACILITY.

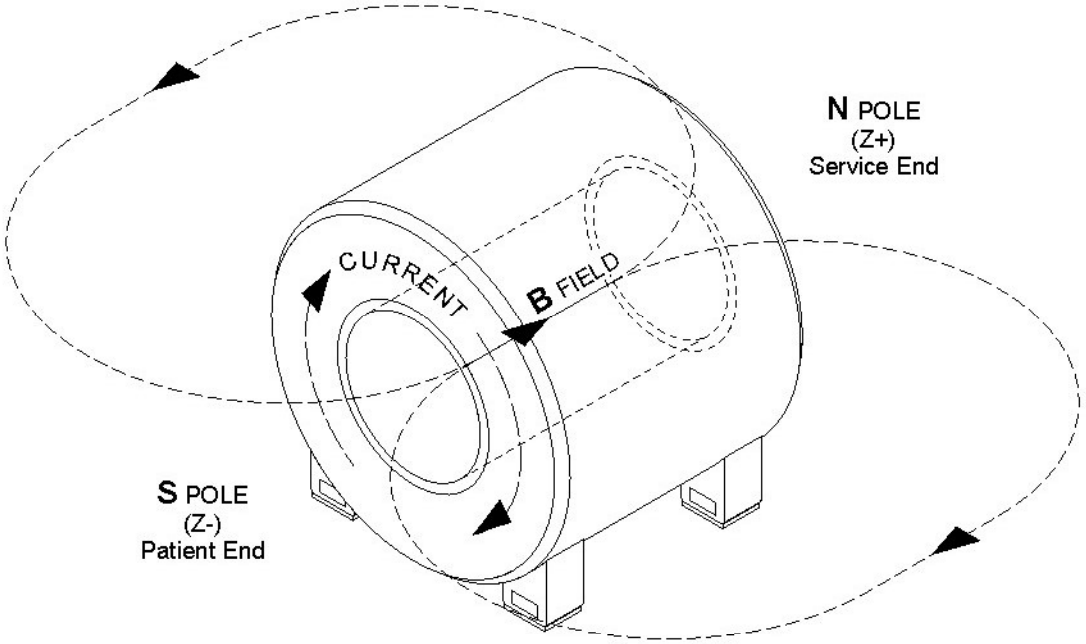
NOTICE

If a Quench occurs during change of magnetic field, immediately turn the Voltage and Current Adjustment Controls to zero.

1. Retrieve the last recorded Main Coil Connection Polarity from Chapter 8, Magnet Ramping and Parking Current Log.

   - Center Frequency will change by about 359 kHz per amp of change in Main Coil current.
   - Main field will have either increased or decreased by the amount recorded in Section 10.4.1, Step 8. For example, a Delta Frequency of +64 kHz indicates the Main Field is too high and will have to be decreased by this amount.

Illustration 3-171: Magnet Polarity Ramped Normal



2. Make sure the Axial Shim Heater is on, and the Main Leads are connected with the polarity retrieved in Step 1.
3. Set the power supply's Voltmeter Select Switch to the MAIN COIL position. (See Illustration 3-169 or Illustration 3-170.)
4. Set the power supply's Current Adjustment Control to maximum (fully CW).

5. Adjust the power supply's Voltage Adjustment Control to the Parking Current value retrieved in Step 1.

6. Turn on the Main Switch Heater.

7. Make sure the Axial Shim Switch Heater power supply is on, and left on throughout the Main Field Adjustment procedure.

8. Allow approximately three (3) minutes for the Main Switch to go resistive.

9. When the Main Switch is resistive, **slowly** adjust the Voltage Adjustment Control until the measured main magnet field Base Frequency matches the desired Center Frequency. This will counter the Delta Frequency calculated in Section 10.4.1, Step 8.

   NOTE: For example, where the calculated Delta Frequency calculated is +64 kHz, the main magnet field Base Frequency needs a -64 kHz adjustment to match the desired Center Frequency.

10. Allow six (6) minutes for field to stabilize, then turn Off the Main Switch Heater.

11. Wait a minimum of 15 minutes for the switch to fully cool and go persistent, then record the current value at which the switch went persistent in Chapter 8, Magnet Ramping and Parking Current Log.

12. When the switch goes persistent, **slowly** turn the power supply's Voltage Adjustment Control to zero (fully CCW) over a two-minute period.

    - Only the last two digits of the Teslameter reading should change while the Voltage Adjustment Control is turned to zero.
    - Any larger decrease in the Teslameter reading indicates the Main Coil Switch is not persistent, and the Voltage Adjustment Control must be slowly returned to the magnet's parking field.

13. Turn off the Axial Shim Heater.

14. Gradually turn the Current Adjustment Controls to zero (fully CCW) over a one-minute period.

15. Turn the Main Power Supply off.

⚠WARNING
ELECTRICAL SHOCK HAZARD!
CONTACT WITH CONNECTORS LEADING TO AN ENERGIZED POWER SUPPLY CAN CAUSE ELECTRICAL SHOCK.
FOLLOW LOTO PROCEDURES WHILE MAKING ELECTRICAL CONNECTIONS TO THE MAIN POWER SUPPLY.

16. Disconnect and LOTO input power to the Main Power Supply. Verify that no voltage is present by using a DVM or equivalent measuring device.

⚠WARNING

POTENTIAL MAGNET QUENCH!
IMPROPER ENGAGEMENT/DISENGAGEMENT OF THE MAIN LEAD EXTENSIONS WITH THE MAIN LEAD PINS CAN CAUSE A RAMPED MAGNET TO QUENCH.
INSERT MAIN LEAD EXTENSIONS ONE AT A TIME AND ALLOW THEM TO COOL SUFFICIENTLY (A FOG OR WATER VAPOR FORMS AROUND THE LEAD EXTENSIONS) BEFORE THEY CONTACT THE MAIN LEAD PINS.

⚠WARNING

ELECTRICAL SHOCK HAZARD!
TOUCHING BOTH MAIN LEAD EXTENSIONS AT THE SAME TIME OR ALLOWING THEM TO CONTACT EACH OTHER WHILE THE MAGNET IS AT FIELD WILL RESULT IN A RAPID DISCHARGE THROUGH THEIR CONTACT POINTS IF THE SWITCH HEATER IS ACTIVATED OR CIRCUIT RESISTANCE DEVELOPS AT THAT MOMENT.
DO NOT TOUCH BOTH MAIN LEAD EXTENSIONS AT THE SAME TIME. DO NOT ALLOW THE MAIN LEAD EXTENSIONS TO CONTACT EACH OTHER.

⚠WARNING

ELECTRICAL SHOCK HAZARD!

DO NOT ALLOW EXPOSED BODY AREAS TO COME IN CONTACT WITH THE CRYOSTAT OR PLUMBING WHILE INSERTING OR EXTRACTING THE MAIN LEAD EXTENSIONS.

⚠WARNING

POTENTIAL COLD BURN HAZARD
CONTACT WITH COLD OBJECTS IS POSSIBLE DURING THE FIELD ADJUSTMENT AFTER SHIMMING PROCEDURE.
WEAR NONABSORBENT LEATHER GLOVES WITH NO HOLES OR TEARS DURING INSERTION OR EXTRACTION OF THE MAIN LEAD EXTENSIONS.

NOTICE

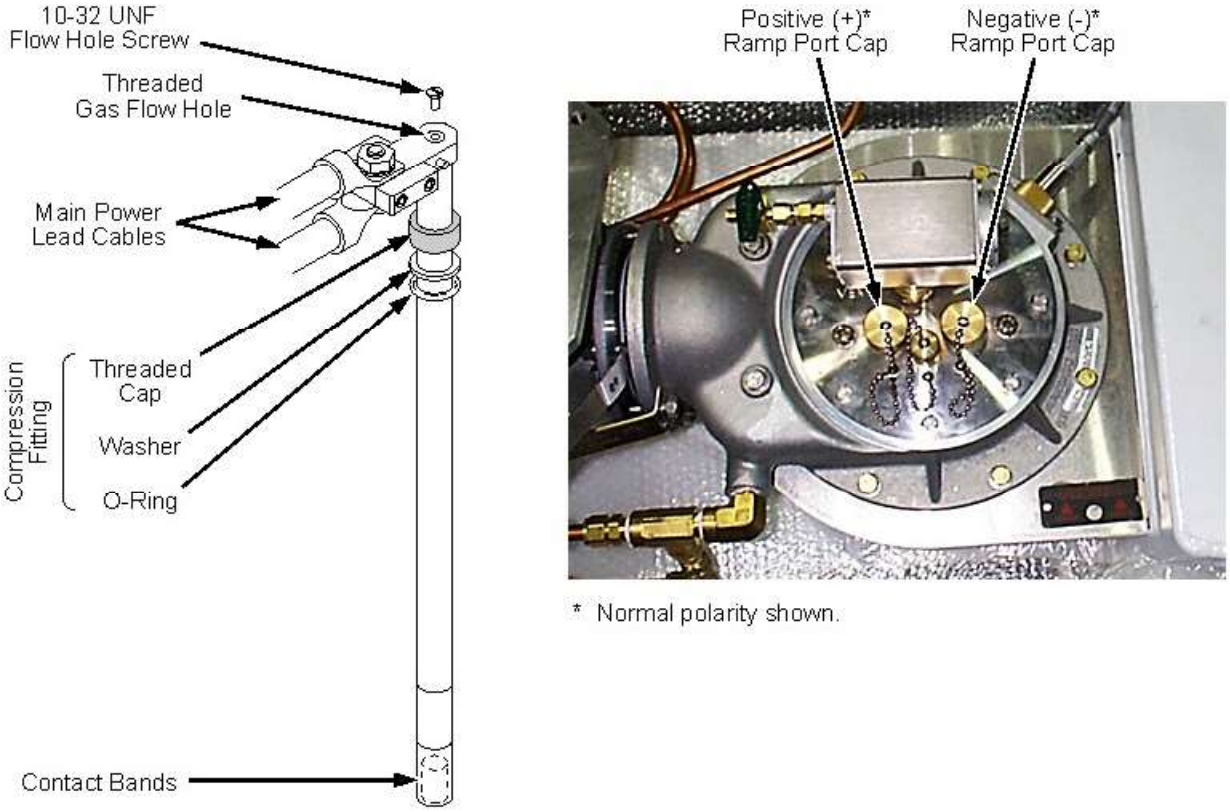
Follow the next step precisely to avoid an excessive heat load being applied to the magnet cartridge and a possible quench following a magnet ramp.

17. After parking the magnet, disconnect and LOTO input power to the Main Power Supply. Verify that no voltage is present by using a DVM or equivalent measuring device. Plug and remove **one** Main Extension at a time in the following sequence:

    a. Open Valve V2, and bleed vessel pressure down below 1.0 psig. (Do **not** allow pressure to go below 0.5 psig as read on the magnet pressure gauge or Magnet Monitor.) Close V2.

b. Remove all ice around the Ramp Lead Port Compression Fitting on the Main Lead Extension that is being removed first. (See the illustration below.)

Illustration 3-172: Main Lead Extension and Ramp Ports



* Normal polarity shown.

⚠WARNING

POTENTIAL MAGNET QUENCH!
PLUGGING THE FLOW HOLE OF AN ENGAGED MAIN LEAD EXTENSION WILL CAUSE THE MAGNET TO QUENCH.
DO NOT INSERT FLOW HOLE SCREWS INTO MAIN LEAD EXTENSIONS UNTIL AFTER EXTENSIONS ARE REMOVED.

c. Unscrew the Ramp Lead Port Compression Fitting, and remove the first Main Lead Extension from the magnet. Immediately replace the cap onto the Ramp Lead Port.

d. Remove all ice around the Ramp Lead Port Compression Fitting on the other Main Lead Extension.

e. Unscrew the Ramp Lead Port Compression Fitting, and remove the second Main Lead Extension from the magnet. Immediately replace the cap onto the Ramp Lead Port.

f. Install the flow hole screws in the flow hole of both Main Lead Extensions **after** both leads are removed.

g. Check the Main Leads and fill port cap for leaks.

10.4.4 Input Shim Currents

⚠CAUTION

Potential Magnet Quench!
The magnet may quench if the Nupro Valve on the Shim Lead is closed or the Shim Lead is not cold.
Make sure the Nupro Valve is fully open and the valve is frosted before slowly engaging the Shim Lead. Do not remove the Shim Lead's Orifice Cap that controls helium gas flow. Always engage/disengage the Shim Lead in conformance with "Shim Lead Engagement and Disengagement."

NOTICE

Before turning on the Shim Coil Power Supply and applying shim currents, make sure the following conditions exist to prevent irreparable damage to the vapor-cooled Shim Leads:

- **Orifice on the Shim Lead vent is in place,**
- **Shim Lead is frosted, and**
- **Power Supply current controls are set to zero (fully CCW).**

1. Make sure the Shim Lead Assembly is engaged in conformance with Shim Lead Engagement and Disengagement.

   NOTE: To frost the Shim Lead, open the Shim Lead Vent Valve. Do not remove the Shim Lead's calibrated orifice.

2. Remove LOTO and reconnect the Shim Power Supply to the magnet in conformance to Connections for Ramping and Shimming. Verify that the Shim Lead Vent Valve is open and the Lead is sufficiently cooled.

3. Switch on the main power to the Shim Power Supply.

4. Input shim currents for one group at a time in the following order:

   - Transverse 1 Coils
   - Transverse 2 Coils)
   - Axial Coils

5. Repeat the following steps for each group in sequence:

   a. Set the Shim Group Select Switch to the appropriate group (T1, T2 or Axial). See Illustration 3-168 and the table below.

Table 3-22: S/C Shim Groups

	Transverse 1 Shim Group	Transverse 2 Shim Group	Axial Shim Group
Course/Fine Adjustment Potentiometer & Polarity Light/Switch	Setting for Shim Group Select Switch		
	Middle	Bottom	Top
	Coil (Circuit)	Coil (Circuit)	Coil (Circuit)
1	T1-1 (ZX^2Y^2)	T2-1 (ZXY)	AX1 (Z^1)
2	T1-2 (X)	T2-2 (Y)	AX2 (Z^2)
3	T1-3 (Z^2X)	T2-3 (Z^2Y)	AX3 (Z^3)
4	T1-4 (ZX)	T2-4 (ZY)	AX4 (Z^4)
5	T1-5 (X^2Y^2)	T2-5 (XY)	AX5* (Z^5)*
6	T1-6 (X^3)*	T2-6 (Y^3)*	AX6 (Z^6)*
* Not applicable to W0 Series LCC300 magnets.			

NOTICE

When the Switch Heaters are turned on, any existing currents in the Shim Coils will be discharged into the Power Supply. To prevent dumping excessive currents through the Shim Leads, match the existing shim currents with the power supply before turning on the heaters. The current then can be adjusted to the required new levels after the heaters are activated.

b. Dial into the Power Supply the last recorded shim currents and polarities from Chapter 8, SC Shimming Data. Make sure the shim current polarities are correct.

c. Make sure the Shim Lead Extension is frosted, then turn on the appropriate Switch Heater.

d. Verify that the T1, T2 and Axial heater currents are within range (T1: 610 mA, ±5 mA; T2: 610 mA, ±5 mA; Axial: 710 mA, ±10 mA). Use the Adjustment Screw on the rear of the Shim Power Supply to make sure the current is within range.

e. Allow five (5) minutes for the heater to drive the Switches resistive.

f. After all the Correction Coil currents are set, make sure each power supply is delivering the appropriate amount of current at the correct polarity.

g. Check the Teslameter's frequency reading to make sure the Correction Coils are stable (i.e., no more than a 20 Hz change in the total magnetic field over a two-minute period).

h. Once the field is stable in the above step, turn off the Switch Heater and allow the heater to cool for 15 minutes.

i. Turn the Shim Power Supply back down to zero amps (fully CCW).

j. Repeat Step 5.a through Step 5.i for the Transverse 2, and Axial Shim Coil groups.

10.5 Finalization

1. Disconnect all cables between the magnet and Shim Power Supply.

NOTICE

Make sure the Shim Lead Vent Valve and Ramp Lead Port Caps are closed, sealed and do not leak to prevent gaseous helium loss and/or frost and ice formation in the Vertical Penetration.

2. Close the Shim Lead's Nupro Vent Valve.
3. Turn off input power to the Shim Power Supply, and disconnect and LOTO all power supply cables. Verify that no voltage is present by using a DVM or equivalent measuring device.
4. Check the magnet's helium level, and add liquid helium in conformance with Liquid Helium Fill if the level is <75%.

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