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**Overview of the physical center fiducialization of tooling balls on spear 3 quads and sextupoles.**

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**Introduction:**

This document contains information on the procedures used on the CMM for the purpose of assigning mechanical X, Y, and Z coordinates to the 6 tooling balls on the Spear 3 quad and sextupole magnets.

**Software:**

There are two routines on the CMM computer that are used to determine the tooling ball values of the magnets (Spear3Quad, Spear3Sext). The routines are programs that execute the necessary steps to complete the data collecting process. Select <copy> from the menu and then highlight the routine you wish to run (e.g. spear3quad or spear3sext.). You will then be prompted to save it. The Default location is A: but you want to change it to C drive. Type the name of the magnet you are working on in the highlighted field. It is now a routine on the C: drive. Select the file you just created. Change from measure to execute on the menu. The routine will now accept data in the correct order. There is a hard copy of both routines on the table by the CMM computer. You may also print out the routine directly from the computer. After the routine is complete, escape to DOS and type <Datacop2>. The program will then ask for the date and operators name. Follow the prompts to copy to the <B> drive.

Datacop2 is a self-written little QBASIC program that handles the details of exporting CMM data to a floppy disk.

**Establishing the Origin:**

The first step of the procedure is to calibrate the three probe tips of the CMM (Figure 1). The first calibration test is to check the probe tips independently. The second is to set the relationship of the three tips together. Once this is done the "yaw" plane of the magnet needs to be determined. Using the upstream face of the Quad, or downstream face on the sextupole, we take 5 measurements to establish a plane. Next we determine roll by taking 2 measurements on the top approximately in the center. One on the plus side and one on the minus side. Once yaw and roll are obtained we need to obtain the "X" origin. By placing the one-piece mandrel (Figure 2) in position one and keeping it secure with four "G10" wedges we take 5 measurements on the upstream and downstream ends. The routine will take the 5 measurements on the one-piece mandrel and calculate a circle giving us the "X" centerline, which also represents the physical centerline. The "Z" position is obtained by taking a measurement on the upstream and downstream faces. The X, Y, and Z planes of the CMM do not match the desired directions used by alignment. To correct for this the routine will now automatically do a coordinate transformation and put the results of all measurements in the correct alignment right hand system. This also is with respect to the mechanical centerline of the magnet.

Figure 1

Figure 2

**Quad Checks:**

After the coordinate system has been determined we check the pitch and roll of the quad using the "VG" grooves. A .500" diameter ball is placed in four grooves close to the top tooling ball locations. It is held down with putty and five measurements are taken for each of the four positions. Starting at position one with the one-piece mandrel we take 5 readings on the upstream and downstream ends. This is repeated for all four mandrel positions.

We now want to do a separate check with the three-piece mandrel (Figure 3). We place the new mandrel in position one and take 5 readings on the upstream and downstream ends. We remove and replace the mandrel back to position one and repeat this step for a total of three iterations. This completes the procedure.

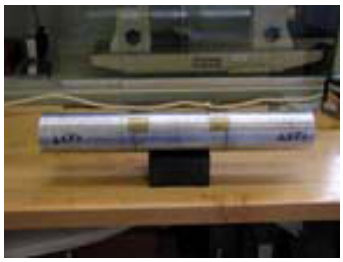

Figure 3

**Sextupole Checks:**

After the coordinate system has been determined we check the sextupole pitch, we do not check roll. We take two line measurements along the top groove. Starting at position one with the one-piece mandrel we take 5 readings on the upstream and downstream ends. This is repeated for all six mandrel positions.

We now want to do a separate check with the three-piece mandrel. We place the new mandrel in position one and take 5 readings on the upstream and downstream ends. We remove and replace the mandrel back to position one and repeat this step for a total of three iterations. This completes the procedure.

**Measuring Pole Tip Gaps:**

The last step in the data collecting process is to measure and record the gaps between the pole tips of the quads and sextupoles. Using gauge blocks (Figure 4) we note the distance between each pole tip. In the unlikely event of having to separate a magnet in the future we will now be able to verify that the magnet is restored back to it's original spacing.

Figure 4

**Displaying Magnet Information On Web:**

The Finished data is copied onto a disk and brought back to the alignment office. The data is then imported into WORD document templates. This is done by "WORD" macros called through a dialog named 'Generate HTMLs'. There is also the choice to add information like the name of the operator, date, and pole tip gap values which are not included in the exported CMM data. Eventually a generation process can be started that makes HTML files out of the WORD documents and puts them into the right directory so that they will show up when the appropriate link on the ' Alignment Engineering for Spear3' web page is clicked.