

# DEVELOPMENT OF COLLAR KEYING PROCEDURES

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MSIM 5/14/91

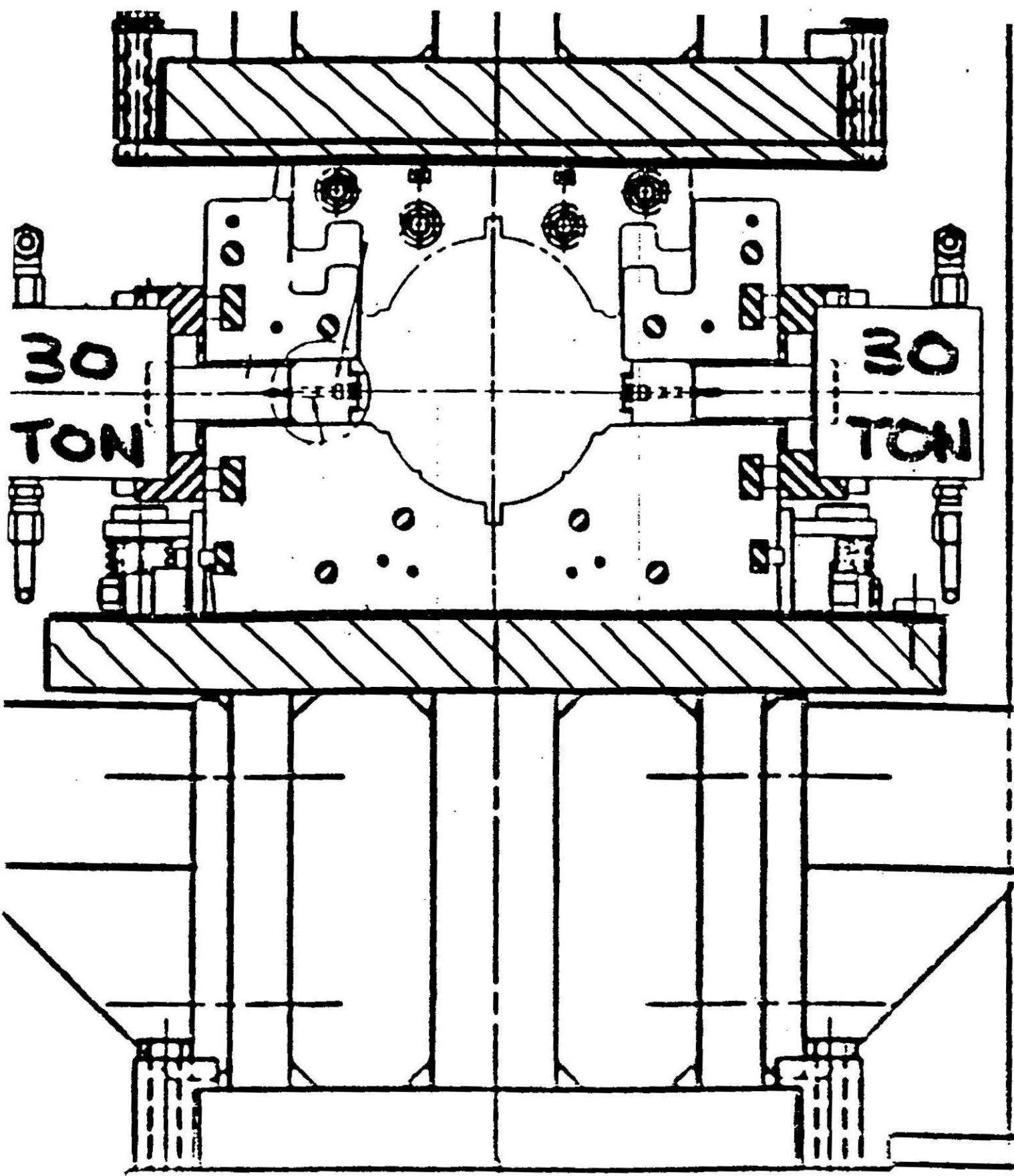
## OBJECTIVES

- 1) OPTIMIZE PROCEDURES TO MINIMIZE PEAK COIL STRESS IN COLLARING PRESS:
  - a) "PRIMARY" METHOD: SET THE KEYS IN ("SQUARE KEY" METHOD).
  - b) "BACKUP" METHOD: DRIVE THE KEYS IN ("TAPERED KEY" METHOD).
- 2) DETERMINE COIL SIZE + POLE SHIM COMBINATION THAT GIVES PRESTRESS IN THE TARGET WINDOW:  $10(8) \pm 2$  KPSI IN THE INNER(OUTER) COIL.
- 3) OPTIMIZING FIELD QUALITY IS NOT A PRIMARY OBJECTIVE BUT HARMONICS ARE MEASURED ON EACH ASSEMBLY

TOOLING IS DESIGNED TO OPERATE IN A "CLOSED CAVITY" CONDITION - COLLARS ARE CLOSED TO A FIXED DIMENSION AND THE KEYS ARE INSERTED.

### OPTIMIZE

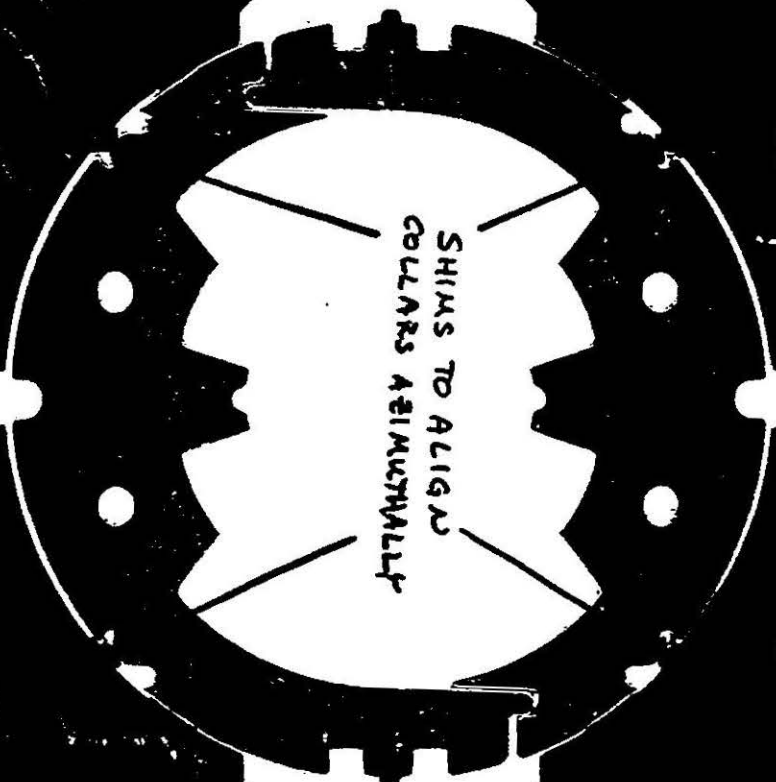
- 1) VERTICAL PRESS STOP TO
  - a) SET KEY INTO COLLARS WITH MINIMAL OVERCOMPRESSION ("SQUARE KEY" METHOD). OR
  - b) DRIVE KEYS INTO COLLARS WITH MINIMAL SIDE FORCE ("TAPERED KEY" METHOD).
- 2) AZIMUTHAL ALIGNMENT OF UPPER RELATIVE TO LOWER COLLARS TO ACHIEVE THE SAME OBJECTIVES.



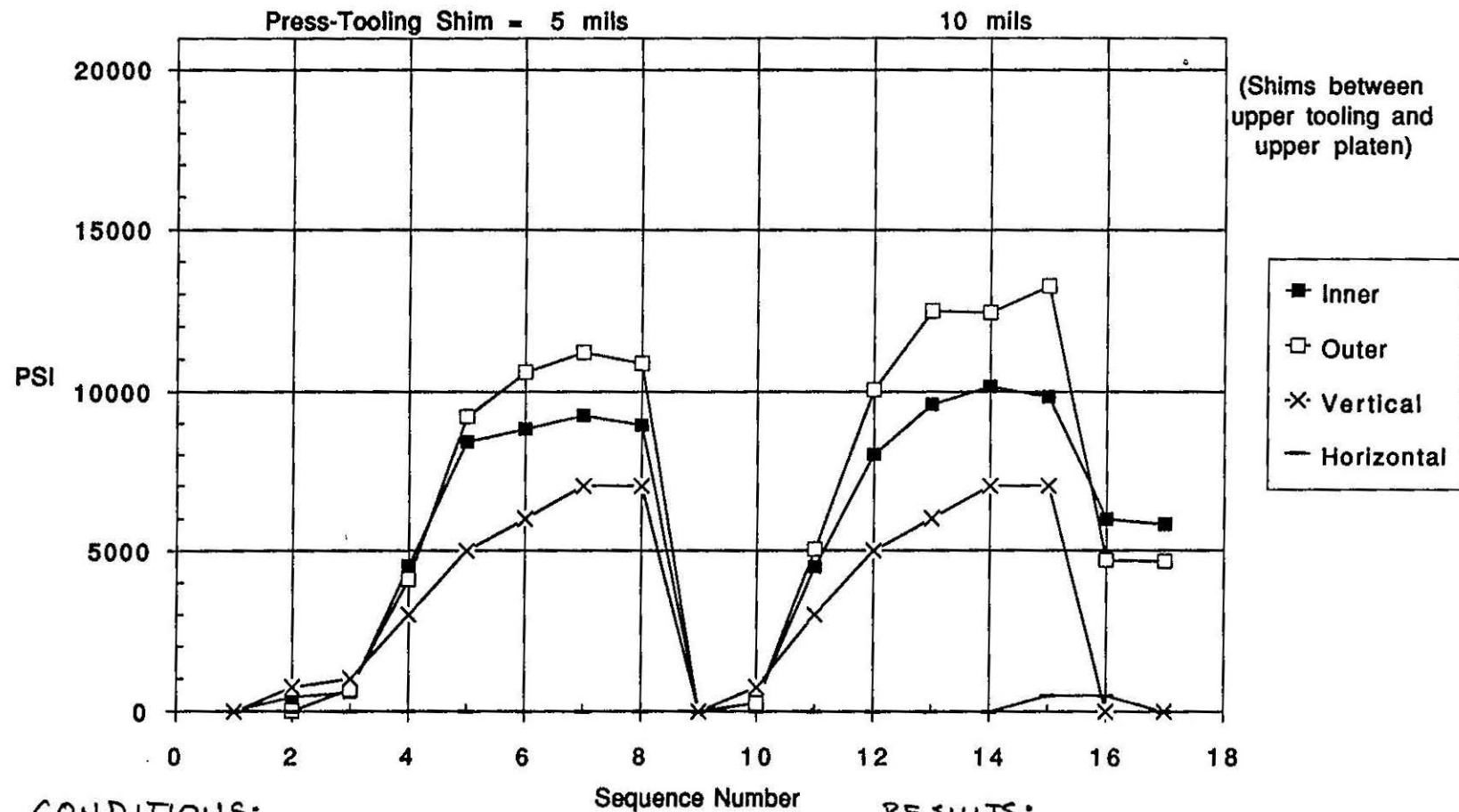
SHIM TO INCREASE COIL COMPRESSION

COIL COMPRESSION

SHIMS TO ALIGN  
COLLARS AXIALLY



DSA322 1st Collaring (1/25/91)



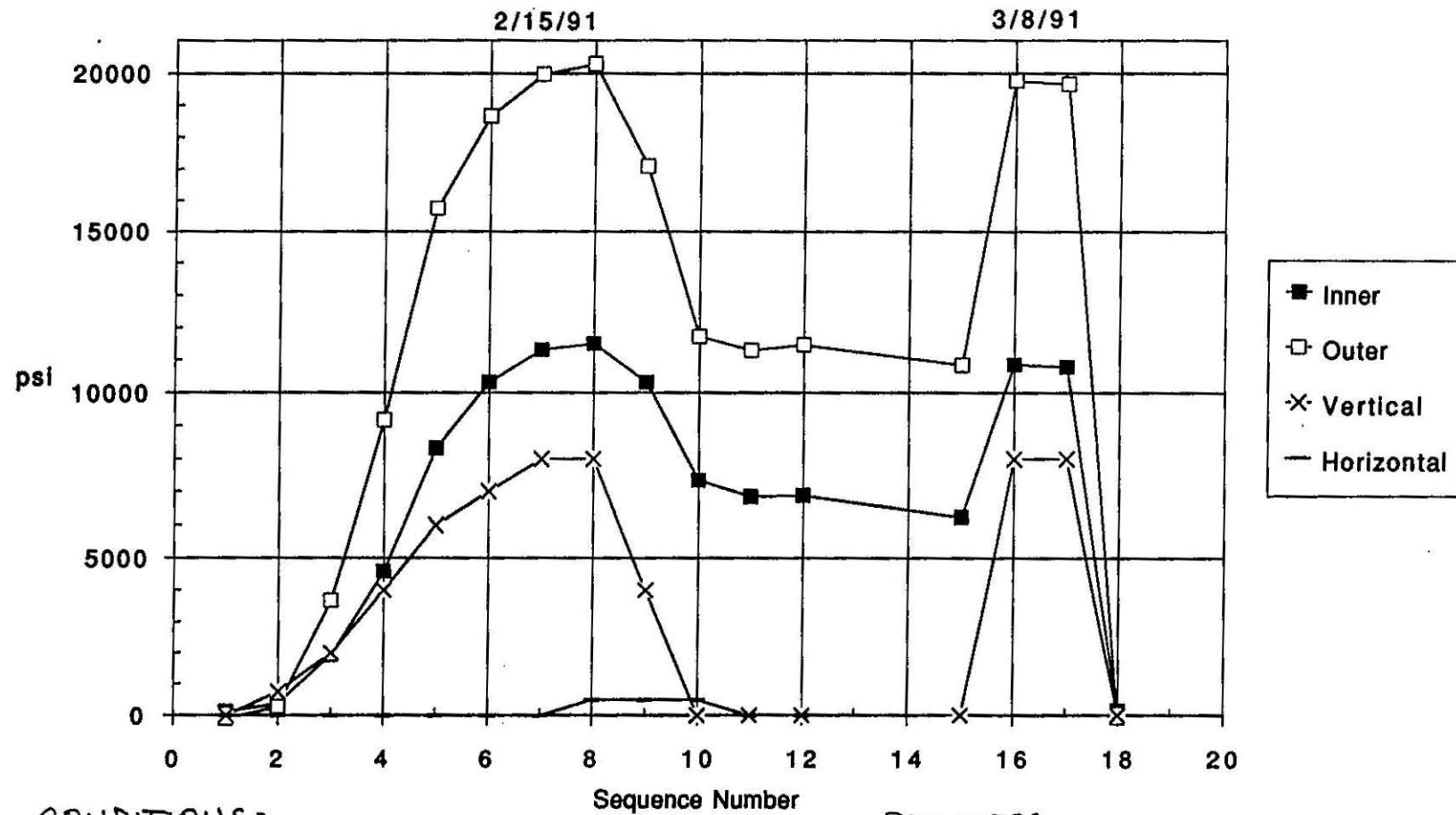
CONDITIONS:

- 1) NO POLE SHIMS
- 2) EDMed TOOLING:  
UPPER - NO AZIMUTHAL  
ALIGNMENT FEATURES

RESULTS:

- 1) SIGNIFICANT AZIMUTHAL MIS-ALIGNMENT  
~ 12-15 mil LEFT-RIGHT COLLAR  
CLOSURE DIFFERENCE
- 2) SIGNIFICANT OVERCOMPRESSION  
REQUIRED TO OVERCOME EFFECT OF (1)

# DSA323 First Assembly and Disassembly



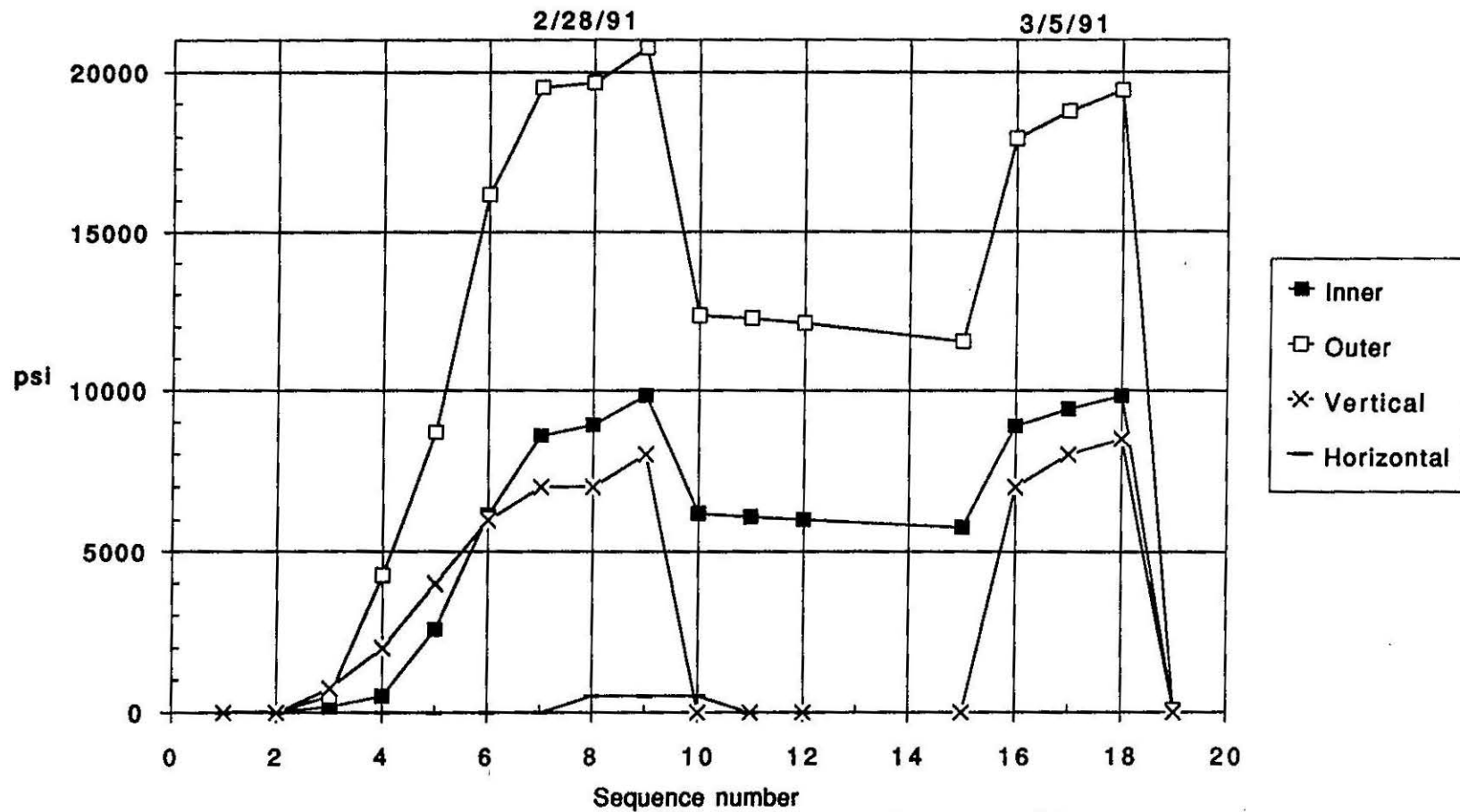
## CONDITIONS:

- 1) NO POLE SHIMS
- 2) LAMINATED UPPER TOOLING,  
HAS ALIGNMENT FEATURES
- 3) 5 mil PRESS STOP SHIM

## RESULTS:

- 1) SIGNIFICANT AZIM. MIS-ALIGNMENT  
~10-12 mil LEFT-RIGHT DIFFERENCE
- 2) KEYS NOT FULLY INSERTED (~10 mils)  
AT 500 LBS./IN.

# DSA322 2nd Collaring



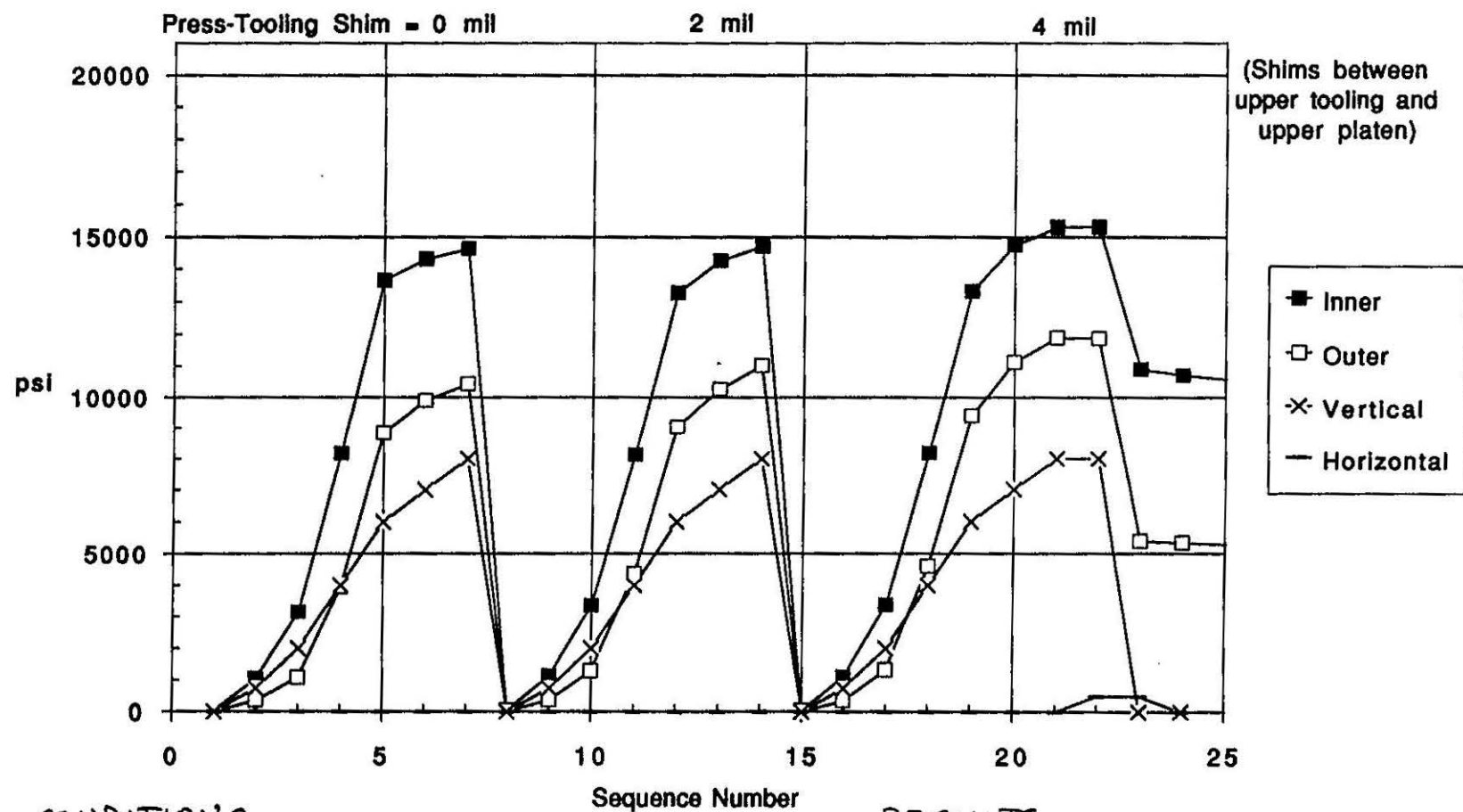
## CONDITIONS:

- 1) NO POLE SHIMS
- 2) 5 MIL "AZIMUTHAL" SHIMS,  
4 QUADRANTS
- 3) 5 MIL PRESS STOP SHIM

## RESULTS:

- 1) NO AZIMUTHAL MIS-ALIGNMENT
- 2) KEYS FULLY INSERTED AT  
500 LBS./IN.

# DSA322 Third Collaring (tapered keys set in)



## CONDITIONS

- 1) +5 (-5) MIL INNER (OUTER) POLE SHIM
- 2) 5 MIL "AZIMUTHAL" SHIMS
- 3) INCREASE PRESS STOP SHIM UNTIL KEYS CAN BE PLACED BY HAND

## RESULTS

- 1) 4 MIL PRESS STOP SHIM OPTIMAL FOR "SQUARE KEY" METHOD
- 2) INNER COIL "SPRING-BACK" = 4.5 KPSI
- 3) NO MID-PLANE INSULATION DAMAGE @ 15 KPSI
- 4) CHOSEN POLE SHIMS GIVE "CORRECT" INNER PRESTRESS, TOO LOW OUTER PRESTR.



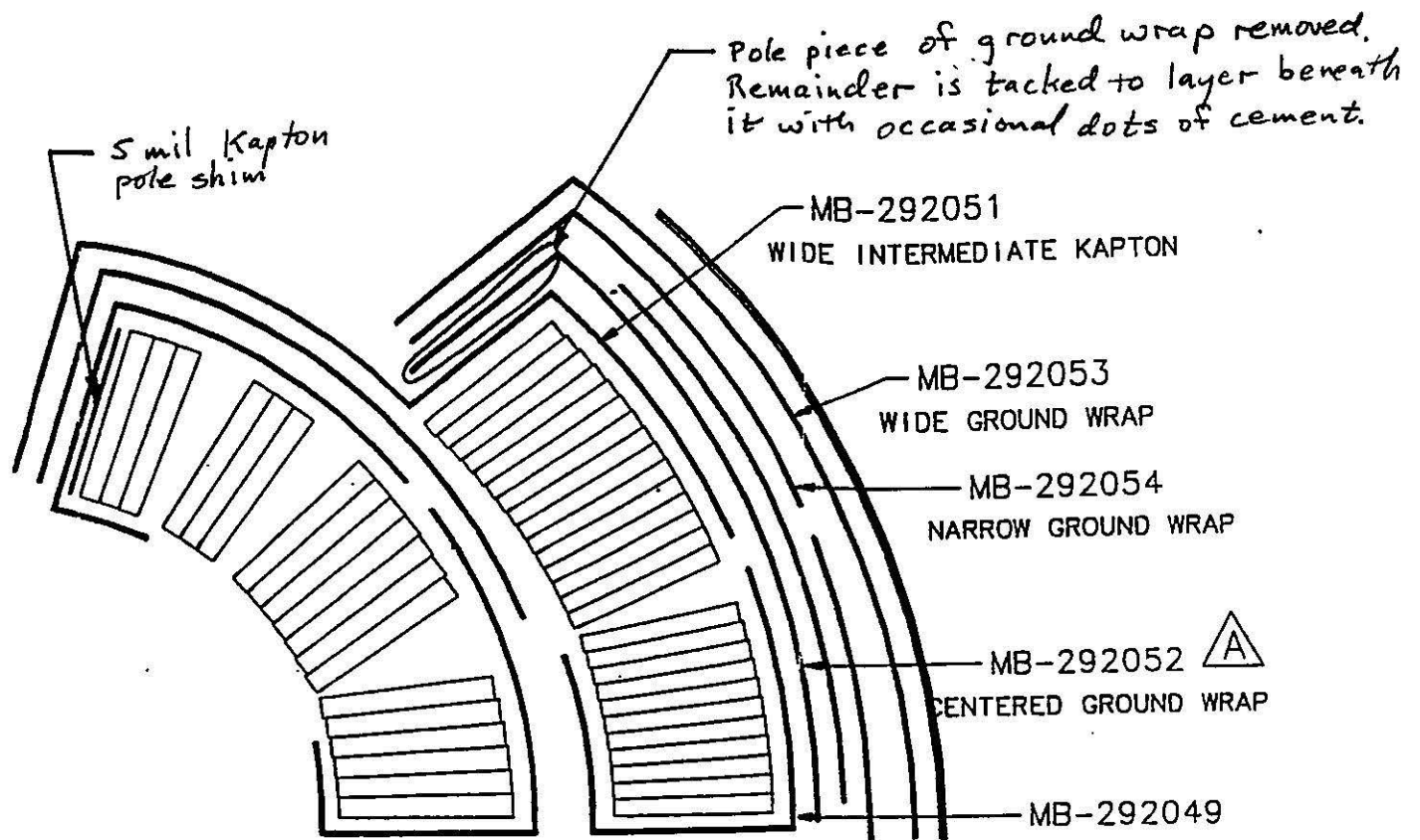
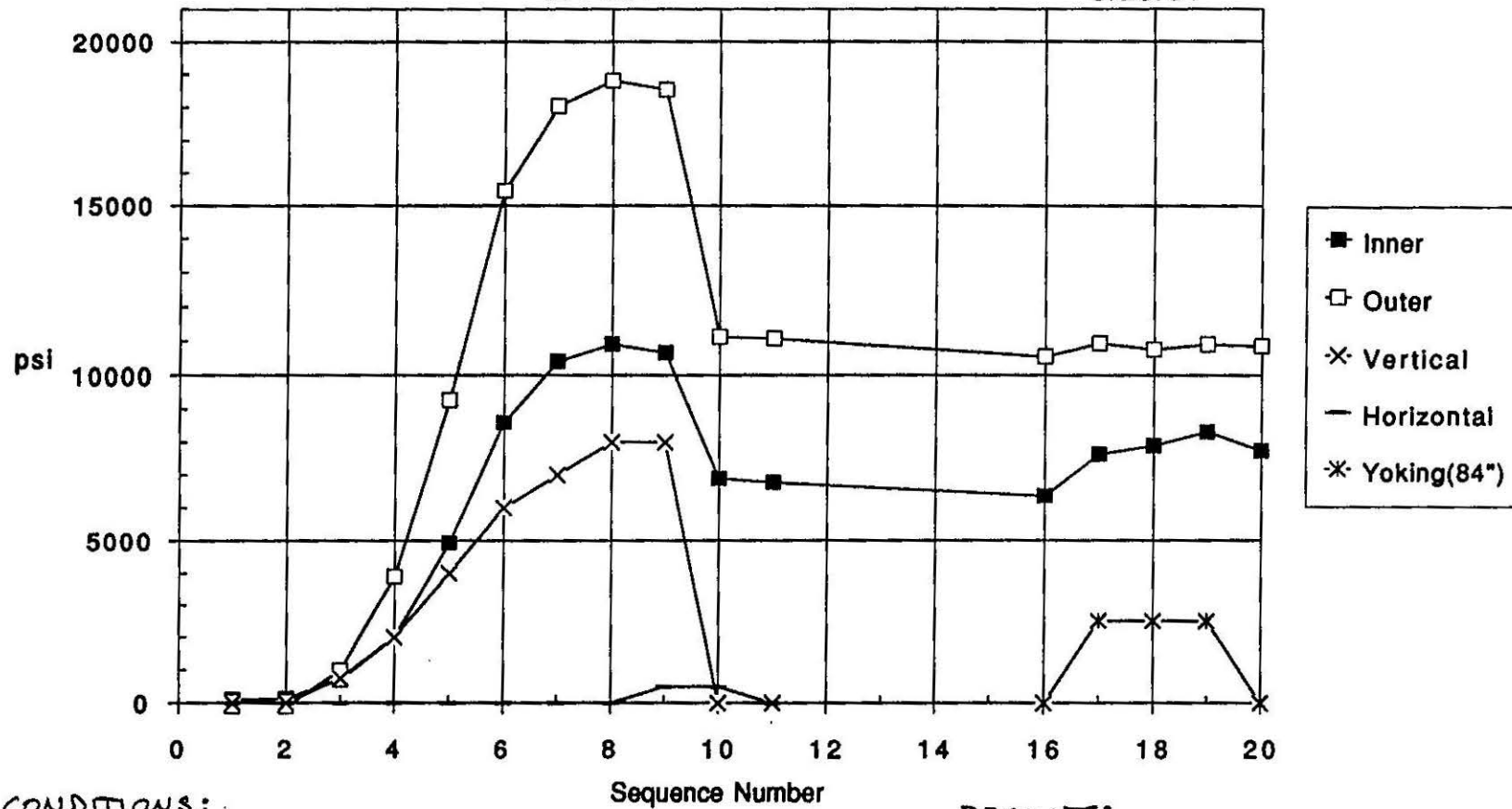


Figure 1

# DSA323 Second Assembly

3/14/91

3/23/91



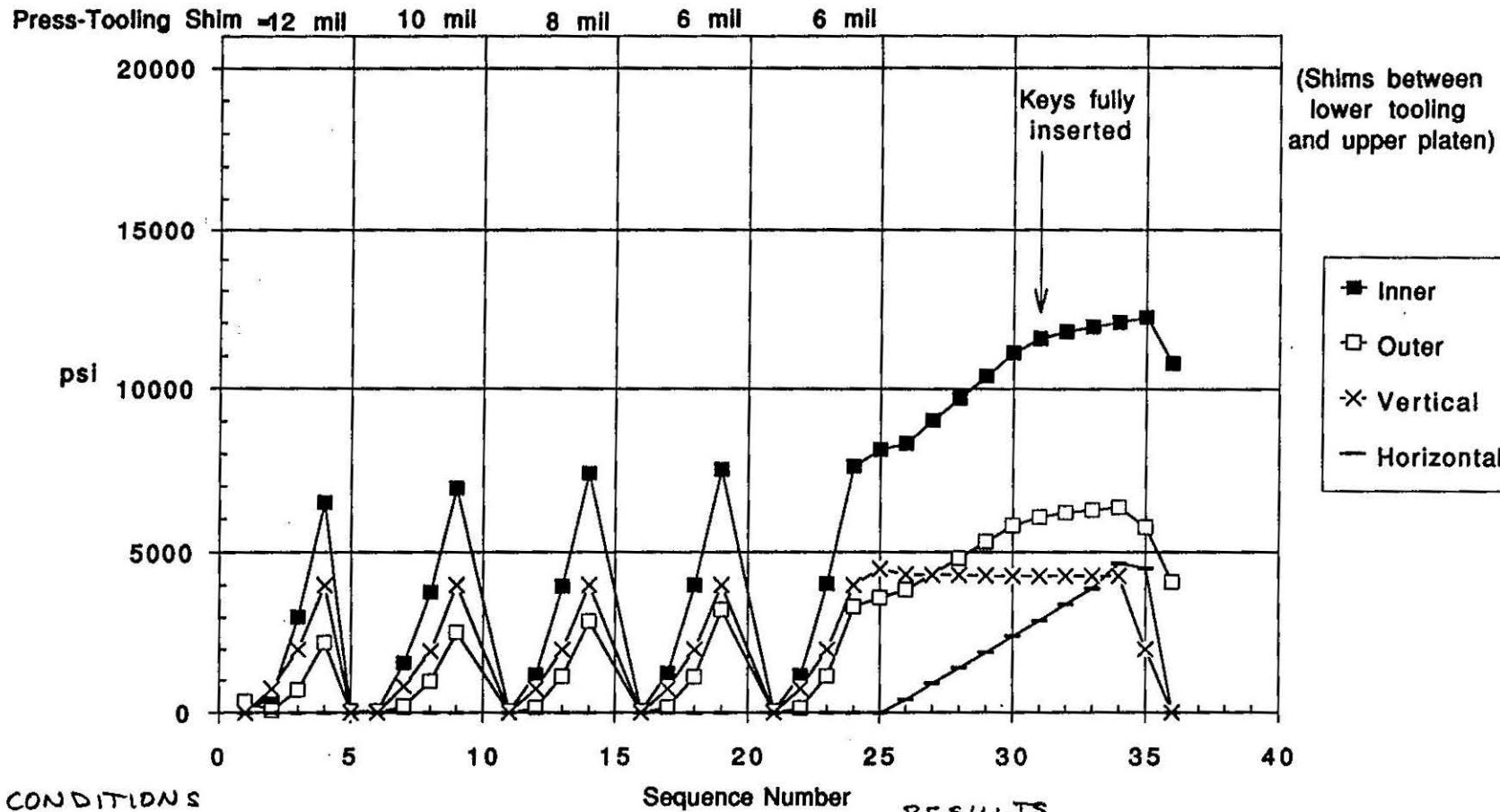
## CONDITIONS:

- 1) NO POLE SHIMS
- 2) TOOLING SETUP THE SAME AS 3RD DSA322 ASSEMBLY

## RESULTS:

- 1) SUCCESSFUL APPLICATION OF "SQUARE KEY" ASSEMBLY METHOD
- 2) 21 KPSI LOWER PEAK STRESS THAN PREVIOUS ASSEMBLY

# DSA322 4th Collaring (tapered keys driven in)



## CONDITIONS

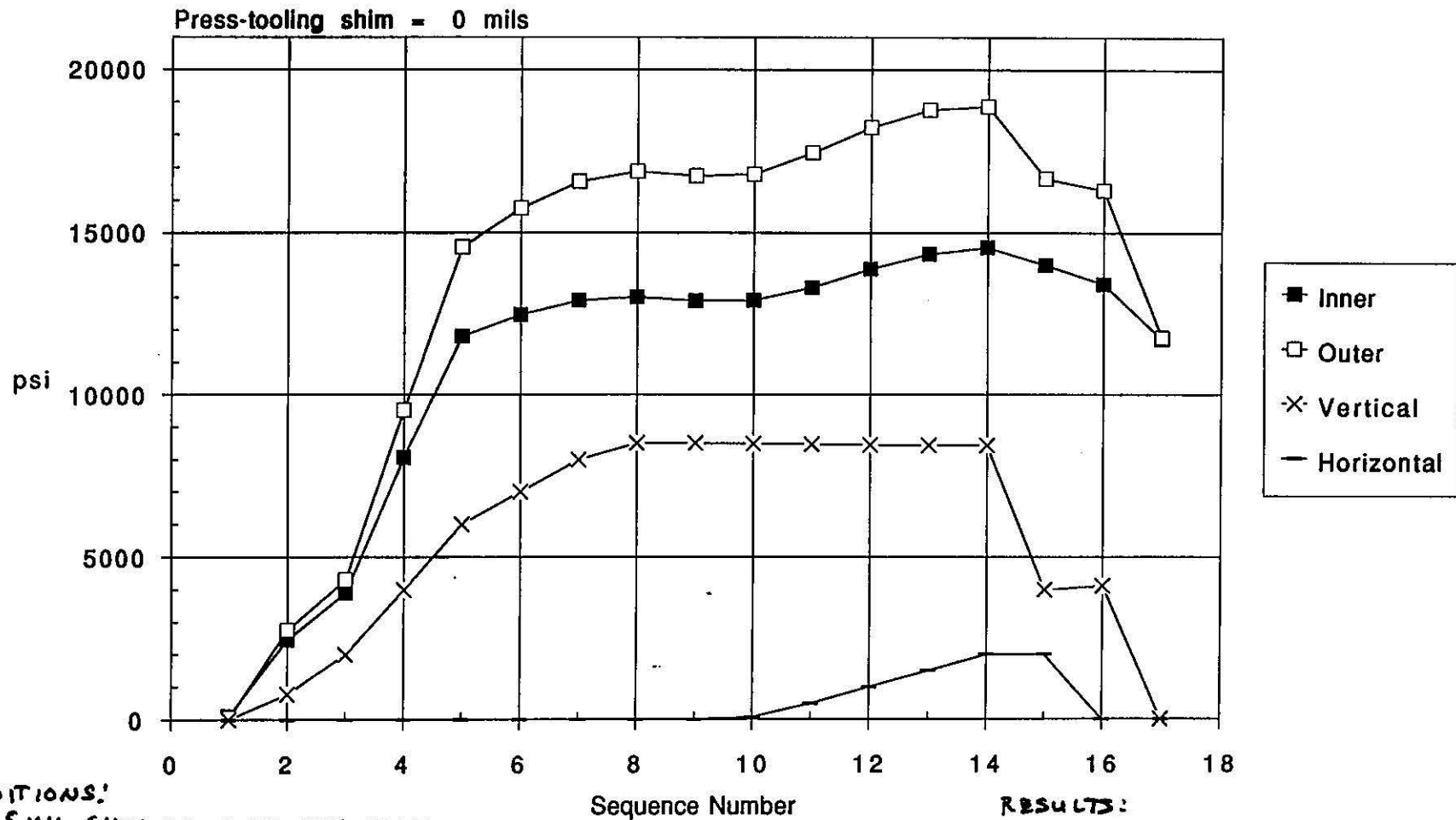
- 1) +5(-5) MIL INNER (OUTER) POLE SHIM
- 2) LAMINATED LOWER TOOLING
- 3) 5 MIL "AZIMUTHAL" SHIMS
- 4) PRESS STOP SHIMS ADJUSTED UNTIL KEYS CAN BE INSERTED 50 MILS

## RESULTS

- 1) "SPRING BACK"  $\approx 1$  KPSI
- 2) TAPERED KEYS DID "MORE WORK" THAN NECESSARY
- 3) EVALUATION RELATIVE TO SQUARE KEY ASSEMBLY IS IN PROGRESS.

# "MIXED" KEY INSERTION

DSA325 Collar Keying (4/8/91)



## CONDITIONS:

- 1) +5 MIL SHIM ON INNER COIL POLE
- 2) OUTER COIL MOLDED IN CAVITY 5 MILS SMALLER THAN PREVIOUS COILS; NO POLE SHIM.
- 3) 5 MIL "AZIMUTHAL" ~~TRONING~~ SHIMS
- 4) NO PRESS STOP SHIM
- 5) KEYS LUBRICATED

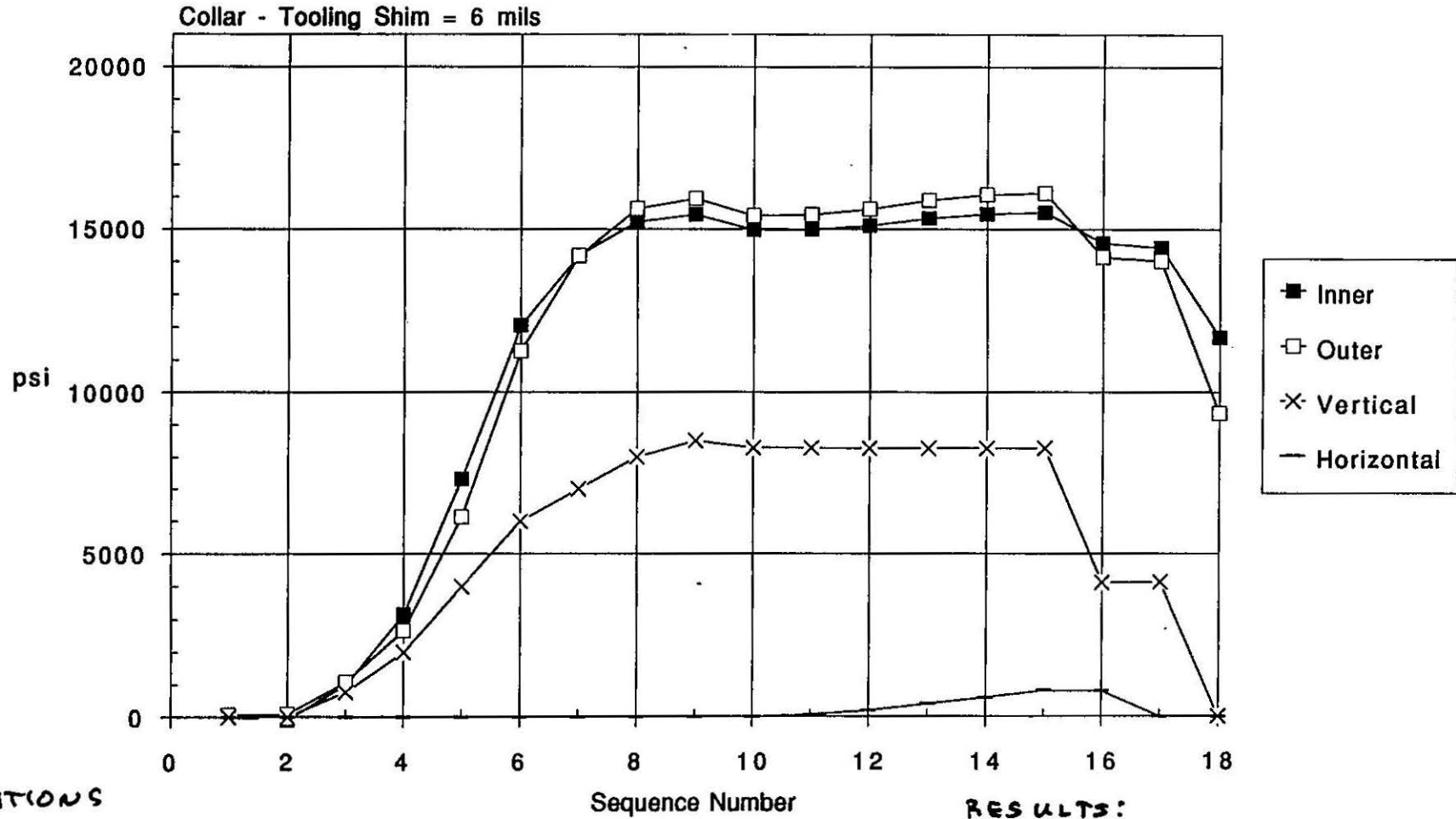
Figure 3

## RESULTS:

- 1) "SPRING BACK" = 3 KPSI (INNER)
- 2) 1500 LBS/IN REQ'D FOR KEY INSERTION.

# "SQUARE KEY" INSERTION

DSA324 Collaring (4/15/91)



## CONDITIONS

- 1) +5(-5) MIL POLE SHIM INNER (OUTER) COIL
- 2) 5 MIL "AZIMUTHAL" TOOLING SHIMS
- 3) PRESS STOP SHIM = 6 MILS
- 4) KEYS LUBRICATED

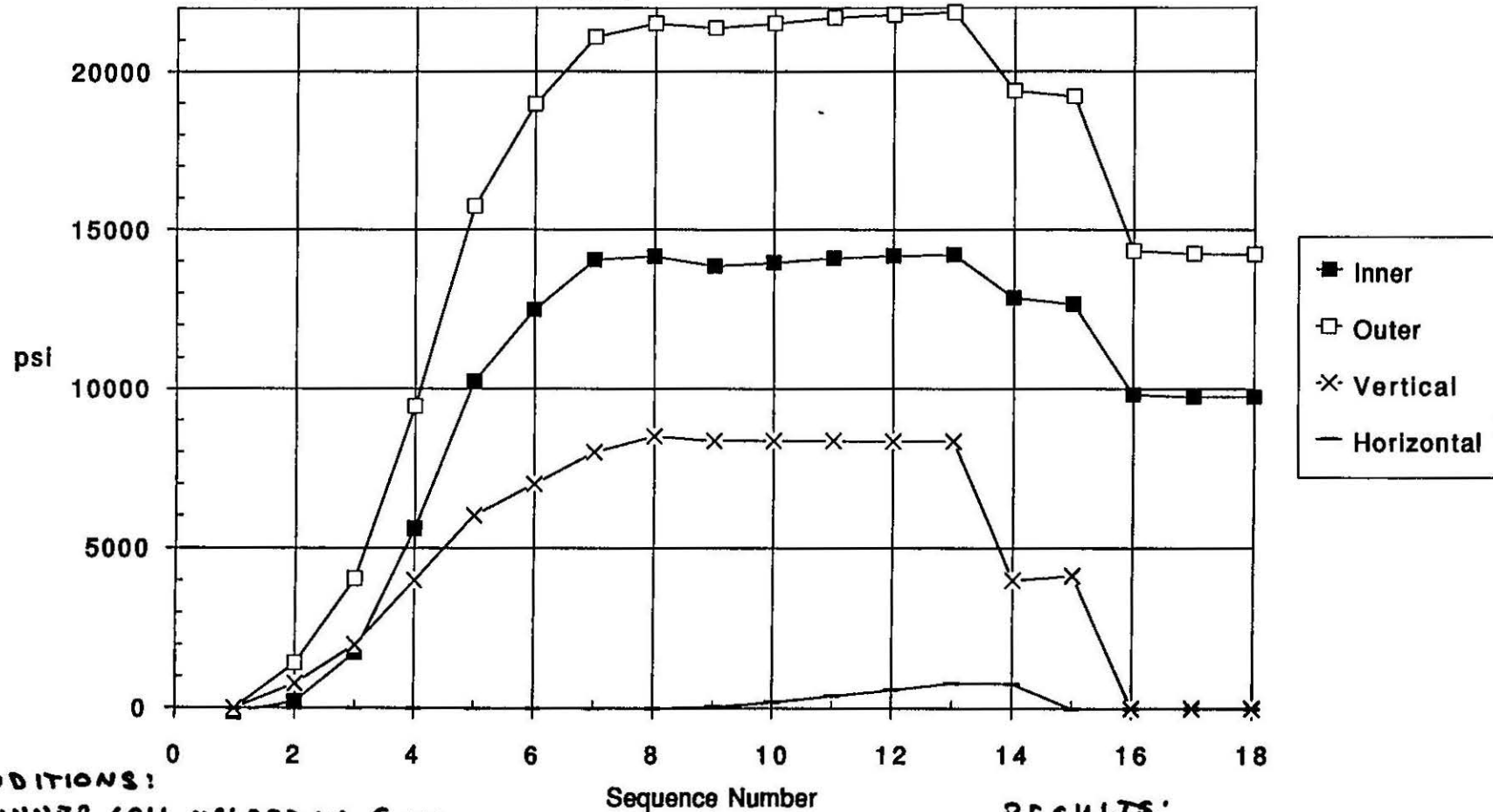
## RESULTS:

- 1) "SPRING BACK" LOSS = 4 KPSI
- 2) 600 LBS/IN REQ'D FOR KEY INSERTION

Figure 3

DSA327 Collaring 5/7/91

PRESS-TOOLING SHIM = 8 MILS



CONDITIONS:

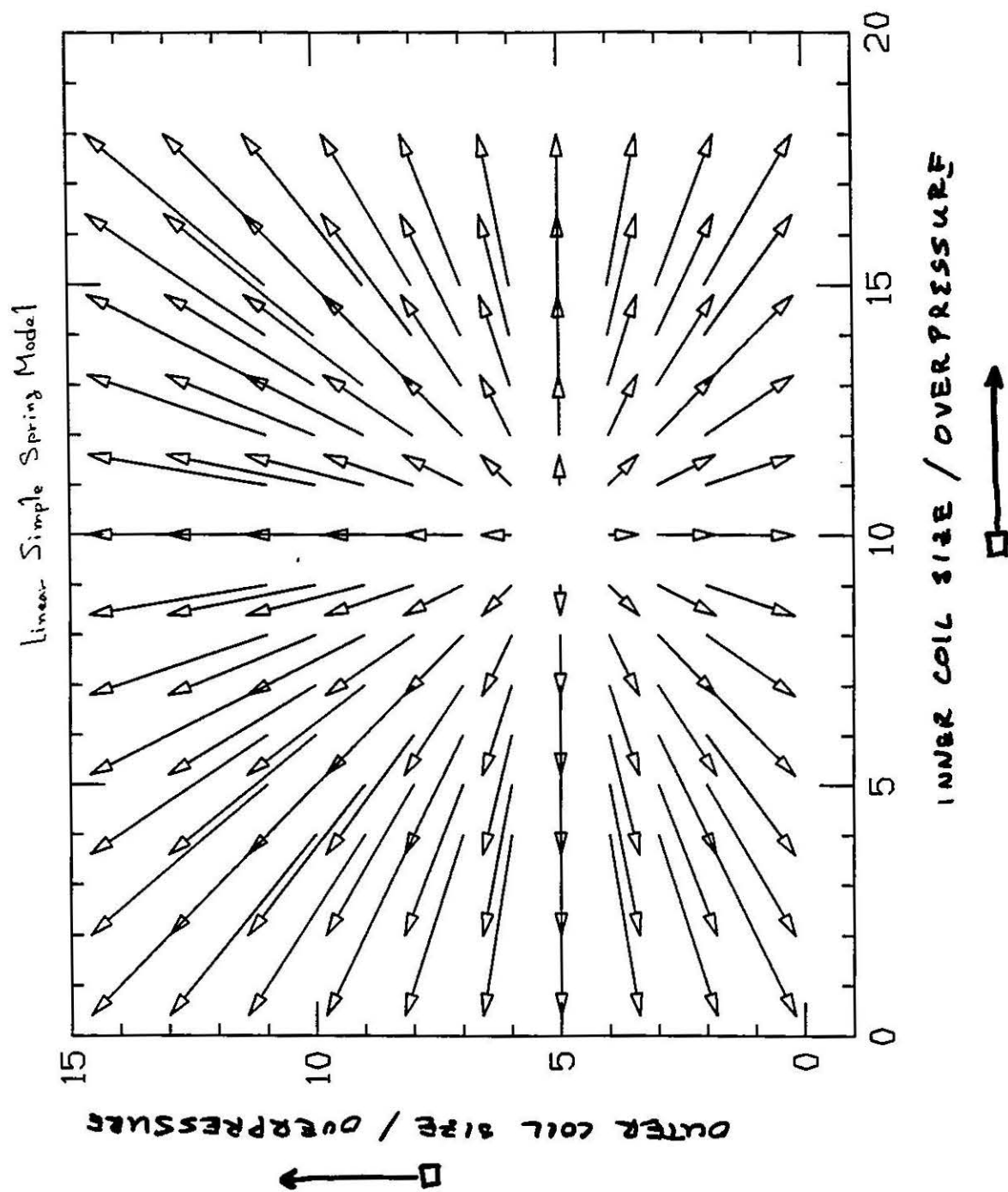
- 1) INNER COIL MOLDED IN 5 MIL OVERSIZE CAVITY
- 2) OUTER COIL MOLDED IN 3 MIL UNDERSIZE CAVITY
- 3) 8 MIL PRESS STOP SHIM
- 4) KEYS LUBRICATED

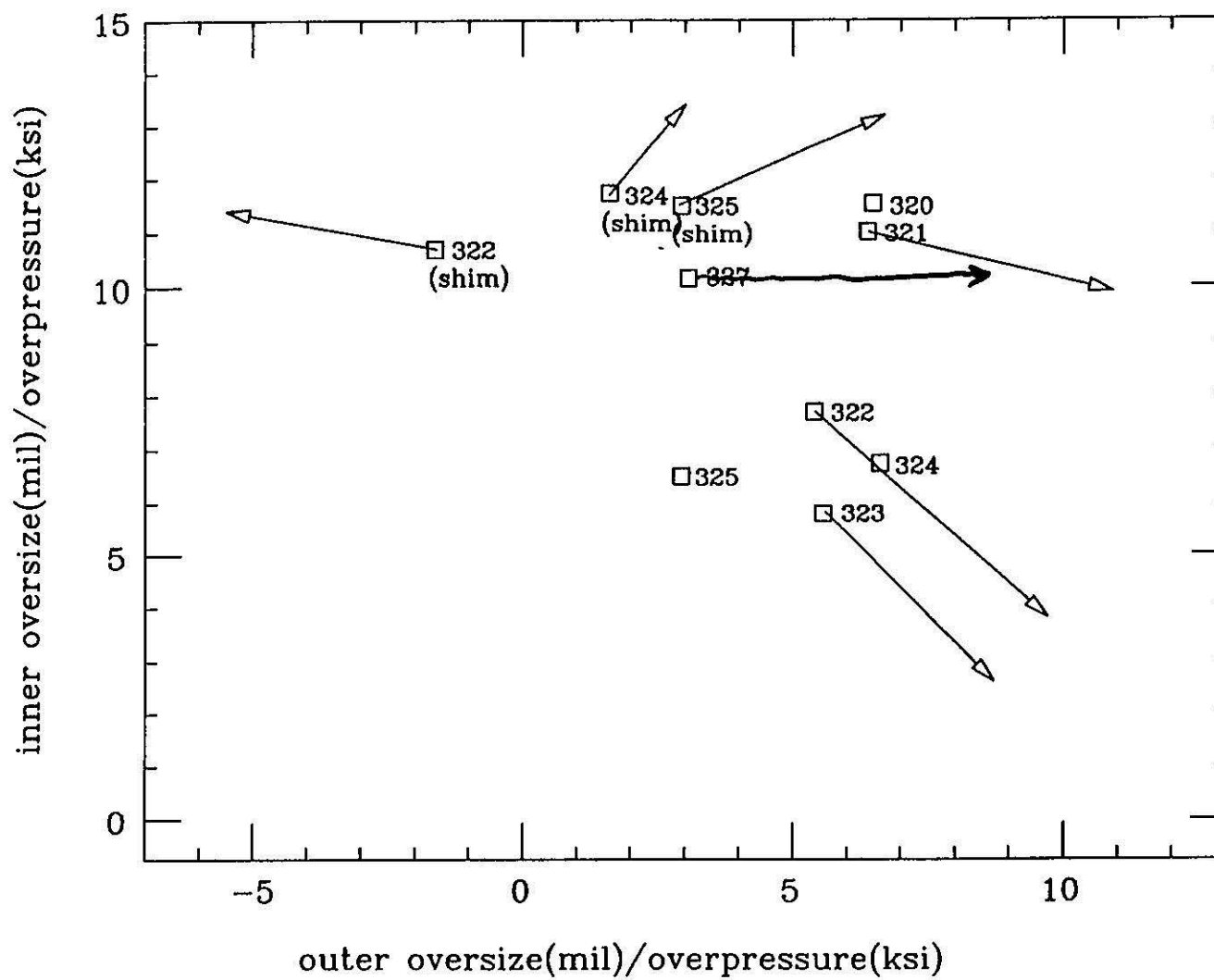
RESULTS:

- 1) 4.5 KPSI INNER "SPRING BACK"
- 2) <400 LBS/IN FOR KEY INSERTION
- 3) OUTER COIL IS STILL TOO LARGE

COIL SIZE/PRESTRESS ANALYSIS  
(MASAYOSHI WAKES)

FIG. 2







Side Bar Travel: dx/dPh

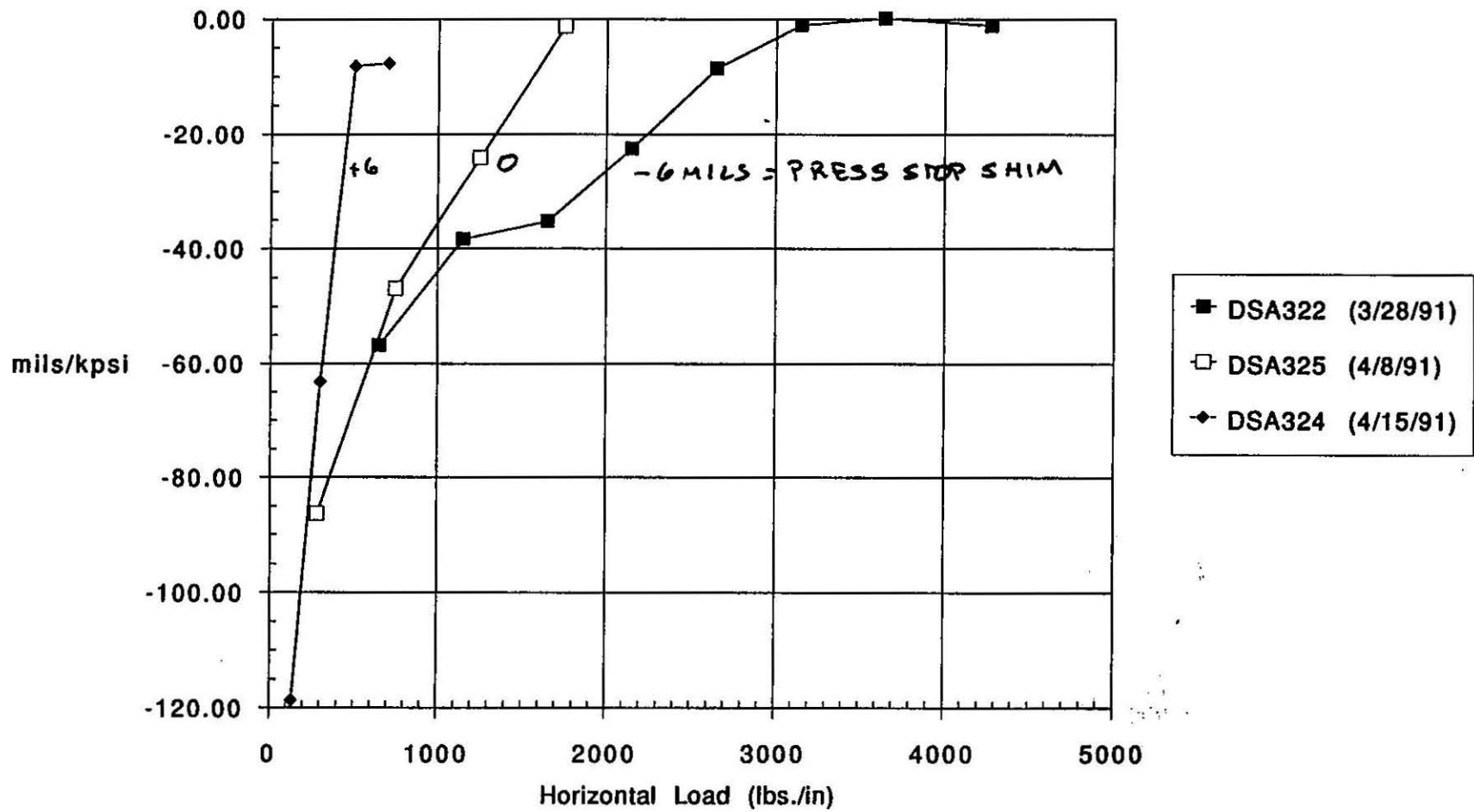
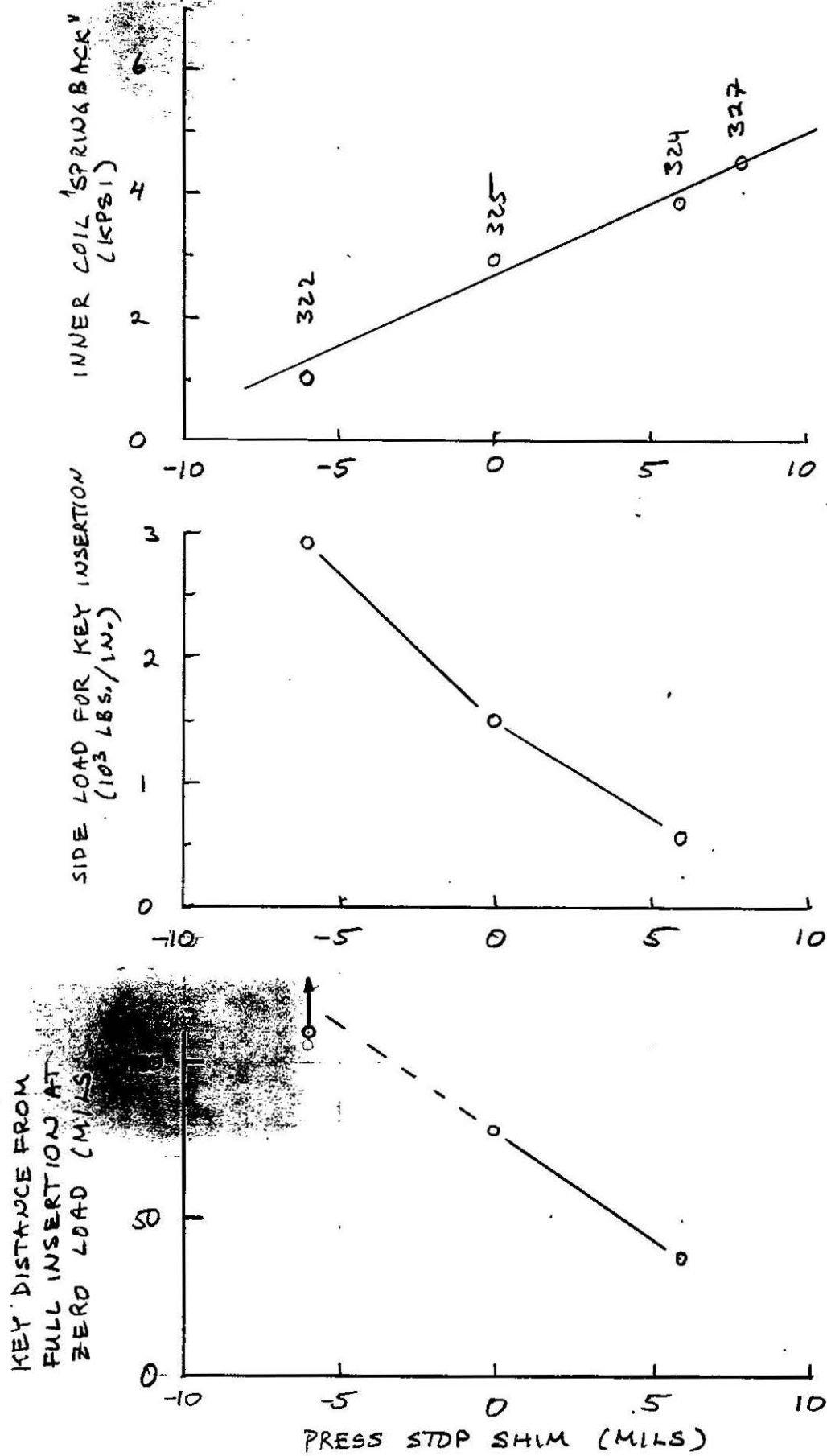


Figure 8



EVALUATION OF COLLAR & KEY  
DEFORMATION DUE TO DRIVING  
THE KEYS INTO DSA322

- 1) DIAMETERS (NEAR  $0^\circ$ ,  $45^\circ$ ,  $90^\circ$ ) OF A COLLAR PACK ASSEMBLED WITH "VIRGIN" KEYS AND NO COIL BEFORE ASSEMBLY ONTO COIL.
- 2) HALF OF DSA322 WAS DISASSEMBLED BY PRYING THE KEYS OUT (SO AS TO NOT STRESS THE COIL ANY MORE THAN DURING KEYING).
- 3) HALF OF DSA322 WAS DISASSEMBLED BY OVERCOMPRESSING THE COLLARS IN THE PRESS AND REMOVING THE KEYS BY HAND (SO AS NOT TO DAMAGE THE COLLARS OR KEYS BEYOND THAT DONE DURING KEY INSERTION).

4) REMEASURE DIAMETERS OF COLLAR  
PACK ASSEMBLED WITH "VIRGIN" KEYS  
AND NO COLL.

|     | <u><math>\Delta r</math></u> |
|-----|------------------------------|
| 12° | +0.3 mils                    |
| 53° | +0.6 mils                    |
| 85° | +0.8 mil                     |
| L/R | +0.8 mils                    |

5) MEASURE DEPTH OF GROOVES SCRAPED  
INTO KEYS BY THE EDGES OF THE  
COLLARS: 0.5  $\leq$  DEPTH  $\leq$  1.0 mils.

$\Rightarrow$  ADDITIONAL VERTICAL "OVALITY"  
OF  $\sim 1.5$  mils ON THE RADIUS

EFFECT OF THIS ON THE HARMONICS  
HAS NOT BEEN CALCULATED (PLANNED)  
BUT IS "PROBABLY" NOT TOO LARGE.

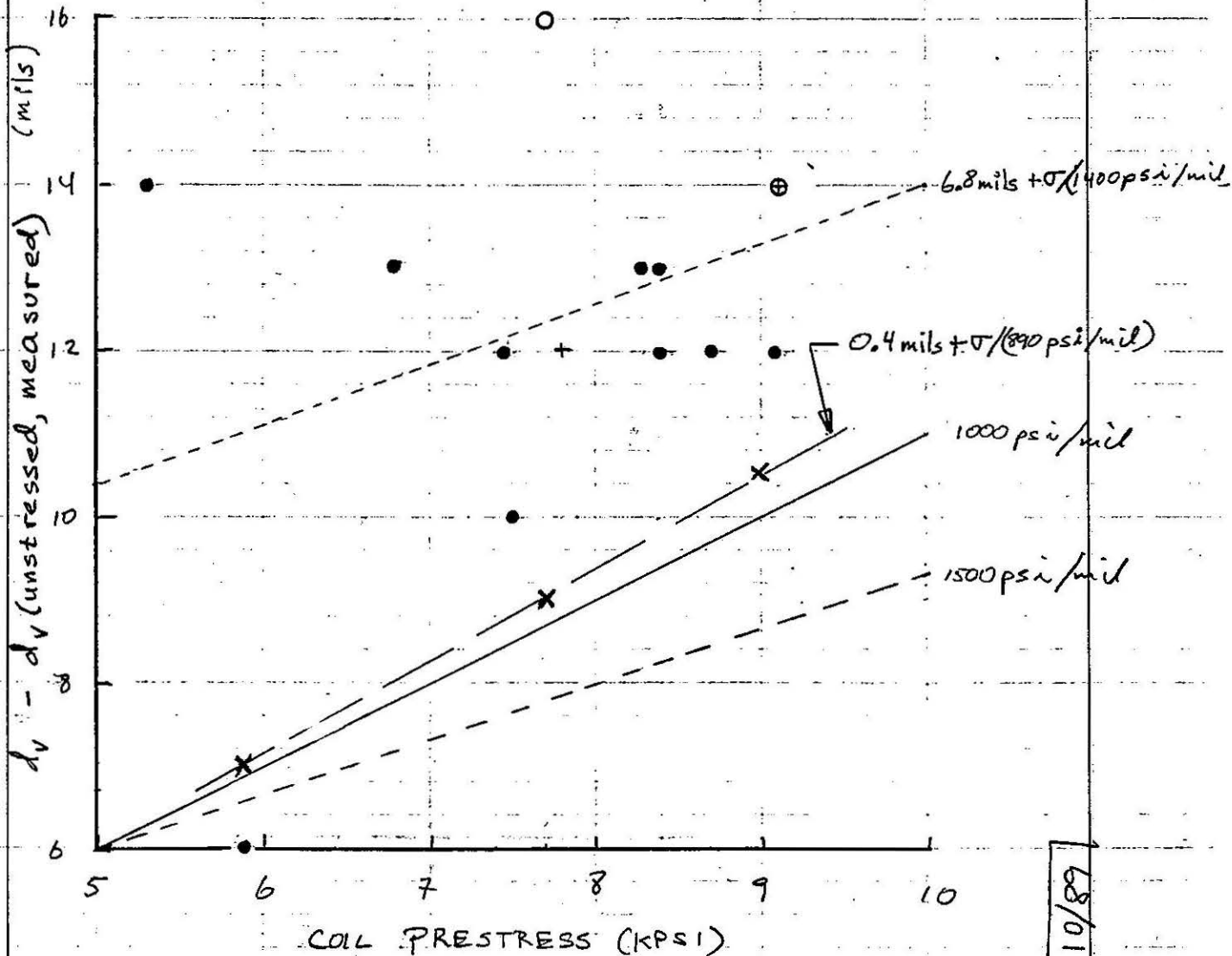
## DSA320-322 Harmonics

| Collared Coil                    | $b_2$           | $b_4$           | POLE SHIMS |       |
|----------------------------------|-----------------|-----------------|------------|-------|
|                                  |                 |                 | INNER      | OUTER |
| DSA320                           | -2.4            | 0.57            | 0          | 0     |
| <del>DSA322 (1st assembly)</del> | <del>-6.2</del> | <del>0.89</del> |            |       |
| DSA322 (2nd assembly)            | -2.9            | 0.48            | 0          | 0     |
| DSA322 (3rd assembly)            | -3.5            | 0.59            | +5         | -5    |
| DSA322 (4th assembly)            | -2.4            | 0.43            | +5         | -5    |
| DSA324                           | -4.1            | 0.31            | +5         | -5    |
| Calculated (w/o iron)            | -4.0            | 0.14            |            |       |
| Complete Magnet                  |                 |                 |            |       |
| DSA321                           | 2.6             | 0.35            |            |       |
| Calculated (with iron)           | 0.2             | 0.07            |            |       |

Figure 3

"EARLY" BNL  
MAGNETS

x "SQUARE" KEYED MAGNETS\*  
 • TAPERED KEYED MAGNETS  
 O. DSS 012  
 + DDO019  
 ⊕ DSK 013



$$\rho = \begin{cases} 0.37 & (\text{all points}) \\ 0.34 & (\text{tapered key, not DSS 012}) \\ 1-2 \times 10^{-5} & (\text{"square" keys}) \\ 0.29 & (\text{all tapered key}) \end{cases}$$

Data from DDO012, 14-19, DSS 010, 12-14, DSK 013

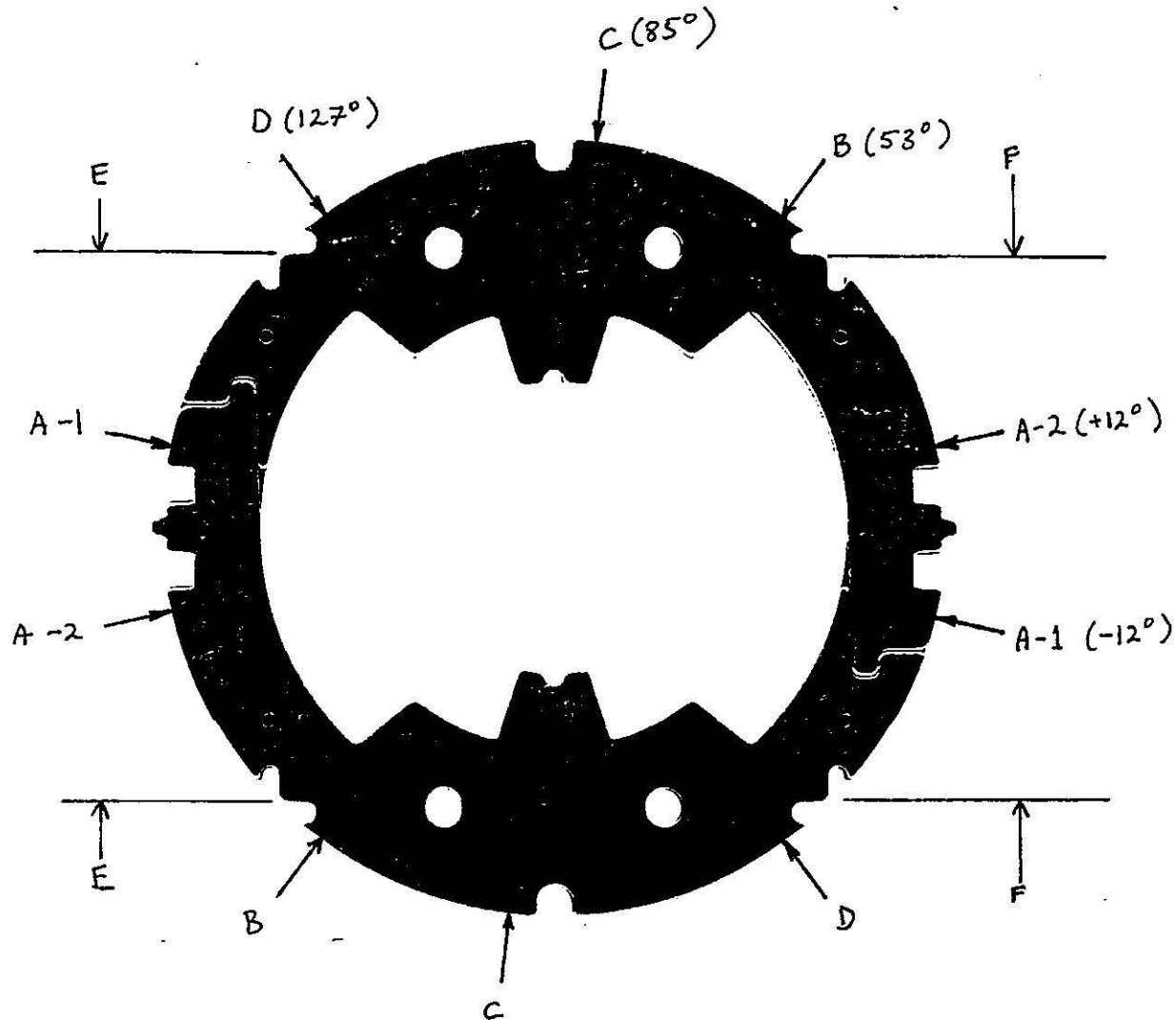
\* includes DSS 14 which has tapered keys but was collared using square key procedures.

PRESENTED AT MSIM ~ 10/89

## DSA322 Assembly Experiment Plan

## III. Second assembly

- 4) Measure collared coil diameters at the angular locations specified on the figure below. Measure the coil at the positions along the length of the coil specified on the table on the next page and record the data there. (These correspond to two sets of measurements per standard collar pack, two sets on the strain gauge pack and one set each on the two end packs.)



Collared Coil Viewed From the Lead End

Measurements are to be made approximately 1/8 inch from the nearest feature that breaks the circular outer surface: the key slots for dimensions A-1 and A-2, the lifting fixture features for dimensions B and D and the instrumentation wire slot for dimension C.

## SUMMARY

- 1) FULL RANGE OF KEY INSERTION TYPES HAS BEEN COVERED BY VARYING THE PRESS STOP BY 14 mils.
- 2) PRESTRESS "SPRING BACK" AND FORCE REQUIRED TO DRIVE THE KEYS IN VARY  $\sim$  LINEARLY WITH AMOUNT OF INITIAL OVER COMPRESSION.
- 3) WITH "FULL" TAPERED KEY INSERTION (3000 LBS/IN TO DRIVE KEYS IN) COLLAR AND KEY DEFORMATIONS RESULT IN  $\Delta r_{\text{VERTICAL}} \cong +1.5$  mils. EFFECT ON FIELD QUALITY IS BEING EVALUATED BUT IS EXPECTED TO BE "NOT TOO LARGE."
- 4) "FINAL" CHOICE OF PRESS STOP FOR LONG MAGNETS HAS NOT BEEN MADE BUT THE PREJUDICE IS FOR A "MIXED" METHOD (A LA DSA325) REQUIRING 1000-2000 LBS/IN. FOR KEY INSERTION.
- 5) INNER COIL SIZE  $\sim$  CORRECT.  
OUTER COIL SIZE NEED FURTHER ADJUSTMENT.