MI-0006

# MAGNETIC DESIGN OF THE MAIN INJECTOR DIPOLE

S. SNOWDON

MI-800

SCS-082289-0830
Ref. MIDIP1

# MAIN INJECTOR DIPOLE

(coil off median plane w/racetrack ends-downsized version)

Contents


| | page |
|---|---|
| 1) References | 1 |
| 2) Performance Parameters | 2 |
| 3) Magnet Cross-Section Profile | 3 |
| 4) 2D Field Calculations | |
| a) Median Plane Field | 3,7 |
| b) Field Harmonics | 4 |
| c) Field Map of Magnet Cross-Section at 17.3kG | 8 |
| 5) 3D Field Calculations | |
| a) Central Field | 5 |
| b) Integrated Field Harmonics | 5 |
| c) Effective Field Length | 5 |
| 6) Figures | |
| a) First Quadrant Magnet Cross Section and Flux Plot | 6 |
| b) Isometric View of Elements in Magnet End Block. | 9 |
| 7) Numerical Tables of Line Elements used in DANCAD3D | 10 |


References

1) 2D Field Code - POISSON/CERN version w/Les Oleksiuk mods
   a) Median Plane Field and Harmonic Analysis
      I= 502A $\mu$=100000 MIDIP-081889-1540
      I=2700A Armco B3 Steel B-H MIDIP-081889-1540
      I=4900A Armco B3 Steel B-H MIDIP-081889-1030
      I=7100A Armco B3 Steel B-H MIDIP-081789-1545
      I=9417A Armco B3 Steel B-H MIDIP-081689-1130
   b) Field Map in Magnet Cross-Section
      I=9417A Armco B3 Steel B-H MIDIP-081789-1545

2) 3D Field Code - GFUN3D/RAL code w/SCS mods(GFS)
   a) I=11000A Armco B3 Steel B-H MIEND-072889-1630

3) 3D Pictorial Representation of Magnet End
   a) DANCAD3D/ver. 1.30 registered with Daniel H. Hudgins

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## Performance Parameters

| | |
|---|---|
| Central Field | 17.30 kG |
| Central Integrated Field | 4152.00 kG-in. |
| Central Radius of Curvature | 954.80 ft |
| Magnet Length (effective - see 3D Field Calculation) | 240.00 in. |
| Sagitta | 0.629 in. |
| Length of End Block (each end) | ~~5.80 in.~~ omit. |
| - iron length | 5.875 in. |
| - magnetic length | 5.800 in. |
| Arc Length of Magnet Body | 228.40 in. |
| Gap Height | ±1.000 in. |
| Good Integrated Field Width -injection | ±1.750 in. |
| -transition | ±1.125 in. |
| -150 GeV | ±0.500 in. |
| Integrated Field Quality within Good Field Region | ±0.015 % |
| Number of Conductor Turns | 4/pole |
| Conductor Current | 9417 A |
| Conductor Cross Section | 1.000 in. by 4.000 in. |
| Conductor Hole Diameter | 0.500 in. |
| Conductor Corner Radius | 0.094 in. |
| Coil Resistance (series connected) | 0.000848 Ω |
| Magnet Inductance | 0.002003 H |
| Voltage Drop (linear ramp w/0.50 sec. rise time) | 37.67 V |
| Voltage Drop (d.c.) | 7.99 V |
| Power Consumed (d.c.) | 75.23 kW |
| Power Consumed (0.50 duty factor) | 37.61 kW |
| Cooling Water Pressure Drop | 65 psi |
| Number of Water Paths in Parallel | 2 |
| Water Flow | 10.8 GPM |
| Temperature Rise (0.50 duty factor) | 13.2 °C |
| Magnet Weight: | |
| - body laminations | 29311 lbs |
| - end blocks (both ends) | ~~2304~~ lbs 1961 |
| Coil Weight (upper pole + lower pole) | 5100 lbs |
| Magnet Size(body) | 29½ in. by 20½ in. |
| (ends) | 32 in. by 23 in. |

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## Profiles

| Iron x(in) | Iron y(in) | Iron x(in) | Iron y(in) | Coil Package x(in) | Coil Package y(in) |
|---|---|---|---|---|---|
| 0.000 | 1.000 | 5.000 | 5.250 | 5.125 | 5.125 |
| 2.250 | 1.000 | 9.750 | 5.250 | 9.625 | 5.125 |
| 2.500 | 0.970 | 9.750 | 0.000 | 9.625 | 1.125 |
| 2.900 | 0.970 | 14.750 | 0.000 | 5.125 | 1.125 |
| 2.986 | 0.992 | 14.750 | 7.750 | 5.125 | 5.125 |
| 3.041 | 1.021 | 12.250 | 10.250 | | |
| 3.193 | 1.178 | 0.000 | 10.250 | | |
| 3.284 | 1.354 | 0.000 | 1.000 | | |

## 2D Field Calculation (x-y calculation)

Median Plane Field ($\Delta B/B_0$ - unit=.0001) - see p. 7 for plot.

| x(in)\$B_0$(kG) | .9932 | 5.304 | 9.621 | 13.848 | 17.300 |
|---|---|---|---|---|---|
| 0.000 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 0.125 | 0.01 | 0.00 | 0.00 | -0.03 | -0.20 |
| 0.250 | 0.02 | 0.01 | 0.00 | -0.09 | -0.60 |
| 0.375 | 0.03 | 0.03 | 0.01 | -0.20 | -1.27 |
| 0.500 | 0.06 | 0.05 | 0.02 | -0.35 | -2.23 |
| 0.625 | 0.11 | 0.09 | 0.04 | -0.56 | -3.52 |
| 0.750 | 0.17 | 0.14 | 0.07 | -0.81 | -5.18 |
| 0.875 | 0.26 | 0.22 | 0.14 | -1.13 | -7.27 |
| 1.000 | 0.38 | 0.33 | 0.20 | -1.51 | -9.88 |
| 1.125 | 0.54 | 0.47 | 0.31 | -1.99 | -13.13 |
| 1.250 | 0.73 | 0.64 | 0.43 | -2.59 | -17.18 |
| 1.375 | 0.91 | 0.78 | 0.53 | -3.39 | -22.31 |
| 1.500 | 0.96 | 0.80 | 0.49 | -4.55 | -28.87 |
| 1.625 | 0.61 | 0.41 | 0.03 | -6.39 | -37.47 |
| 1.750 | -0.74 | -0.98 | -1.44 | -9.56 | -49.05 |
| 1.875 | -4.30 | -4.60 | -5.14 | -15.32 | -65.17 |
| 2.000 | -12.33 | -12.68 | -13.32 | -25.95 | -88.32 |

Field Map in Magnet Cross Section at $B_0$=17.3kG - see p.8

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2D Field Calculation (x-y calculation)

Field Harmonics at 1.00 in. radius. Armco B3 Steel except as noted

| | I=502A $\mu=10^5$ Ampfac=1.0 | | I=2700A Ampfac=1.0072 | |
|---|---|---|---|---|
| N | BN(kG) | RN | BN(kG) | RN |
| 1 | 0.993241 | 1.0000000 | 5.303914 | 1.0000000 |
| 2 | -0.000000 | -0.0000000 | -0.000000 | -0.0000000 |
| 3 | 0.000020 | 0.0000204 | 0.000083 | 0.0000157 |
| 4 | -0.000000 | -0.0000000 | -0.000000 | -0.0000000 |
| 5 | 0.000016 | 0.0000156 | 0.000078 | 0.0000147 |
| 6 | -0.000000 | -0.0000000 | -0.000000 | -0.0000000 |
| 7 | 0.000004 | 0.0000036 | 0.000019 | 0.0000035 |

| | I=4900A Ampfac=1.0077 | | I=7100A Ampfac=1.0144 | |
|---|---|---|---|---|
| N | BN(kG) | RN | BN(kG) | RN |
| 1 | 9.621290 | 1.0000000 | 13.848178 | 1.0000000 |
| 2 | -0.000000 | -0.0000000 | -0.000000 | -0.0000000 |
| 3 | 0.000037 | 0.0000038 | -0.001865 | -0.0001346 |
| 4 | -0.000000 | -0.0000000 | -0.000000 | -0.0000000 |
| 5 | 0.000134 | 0.0000139 | -0.000186 | -0.0000134 |
| 6 | -0.000000 | -0.0000000 | -0.000000 | -0.0000000 |
| 7 | 0.000033 | 0.0000034 | -0.000013 | -0.0000009 |

| | I=9417A Ampfac=1.0770 | |
|---|---|---|
| N | BN(kG) | RN |
| 1 | 17.299926 | 1.0000000 |
| 2 | -0.000000 | -0.0000000 |
| 3 | -0.014346 | -0.0008292 |
| 4 | -0.000000 | -0.0000000 |
| 5 | -0.002167 | -0.0001253 |
| 6 | -0.000000 | -0.0000000 |
| 7 | -0.000396 | -0.0000229 |

3D Field End Simulation (x-y-z calculation w/Armco B3 steel B-H)

Central Field (B0 in midsection) 16.508687 kG

Integrated Field Harmonics at 1.00 in. radius

| N | GN (kG-in.) | RN |
|---|---|---|
| 1 | 95.778961 | 1.000000 |
| 3 | 0.090973 | 0.000950 |
| 5 | -0.055411 | -0.000579 |
| 7 | 0.011131 | 0.000116 |

Effective Length of End Block

95.77896/16.50869=5.80 in.

Thus the body section (29½" by 20½") terminates 5.80 in. in from the effective entrance plane and 5.80 in. in from the effective exit plane; the distance between the planes being 20 ft.

Iron Length of End Block: 4.000 + 1.875 = 5.875in.

Hence the effective field termination planes are inside the iron termination planes by: 5.875 - 5.800 = 0.075in. at each end.

Arc Length of Magnet Body:

The desired effective magnetic length is 20 ft or 240.00 in. Subtracting 5.80 in. from each end gives:

240.00 - 2*5.80 = 228.40

Isometric View of Elements in End Block - see p. 9

Numerical Tables of Line Elements of End Block - see p. 10

Underlined points 1,2,3,·····,10 represent end shim bump.

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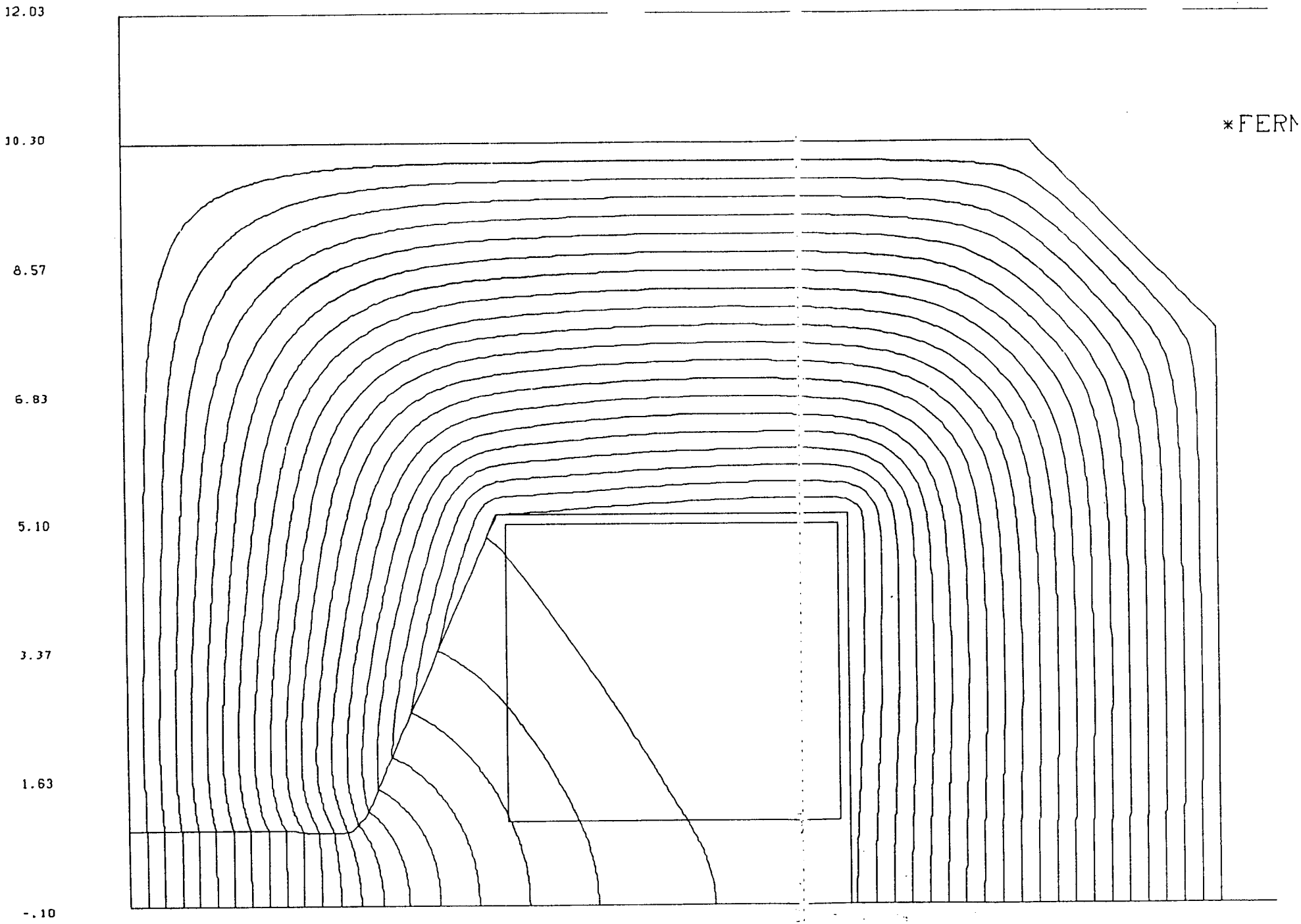


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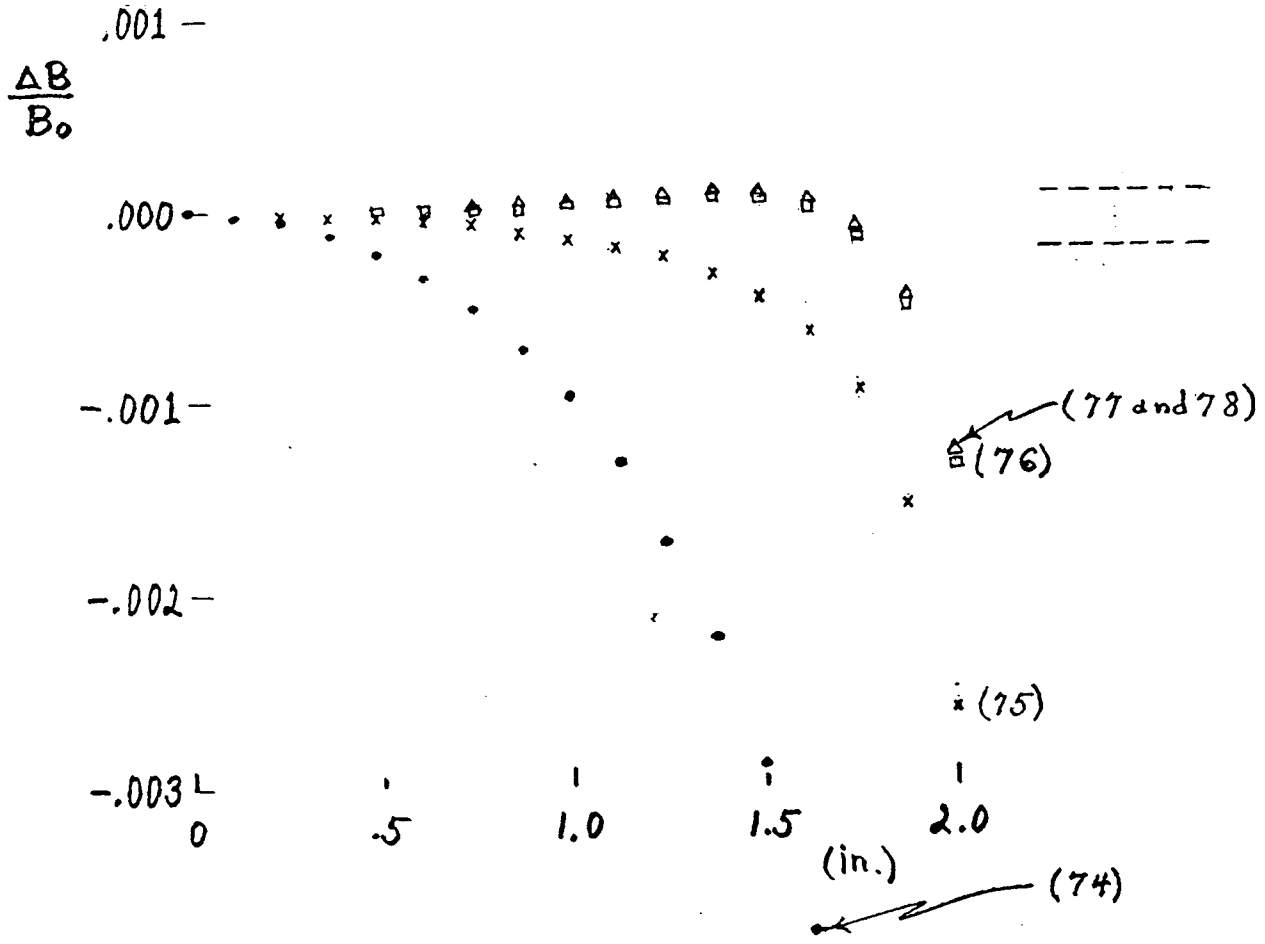
# 2D-Field Quality ($\Delta B/B_o = \pm .00015$)

## Armco B3 Steel B-H

| Run | I (A) | $B_o$ (kG) | GFLD (in.) | Ampfac |
|---|---|---|---|---|
| 74 | 9417 | 17.300 | ±0.50 | 1.0770 |
| 75 | 7100 | 13.848 | ±1.125 | 1.0144 |
| 76 | 4900 | 9.621 | ±1.75 | 1.0077 |
| 77 | 2700 | 5.304 | ±1.75 | 1.0072 |
| 78 | 502 | .993 | ±1.75 | 1.0000 |

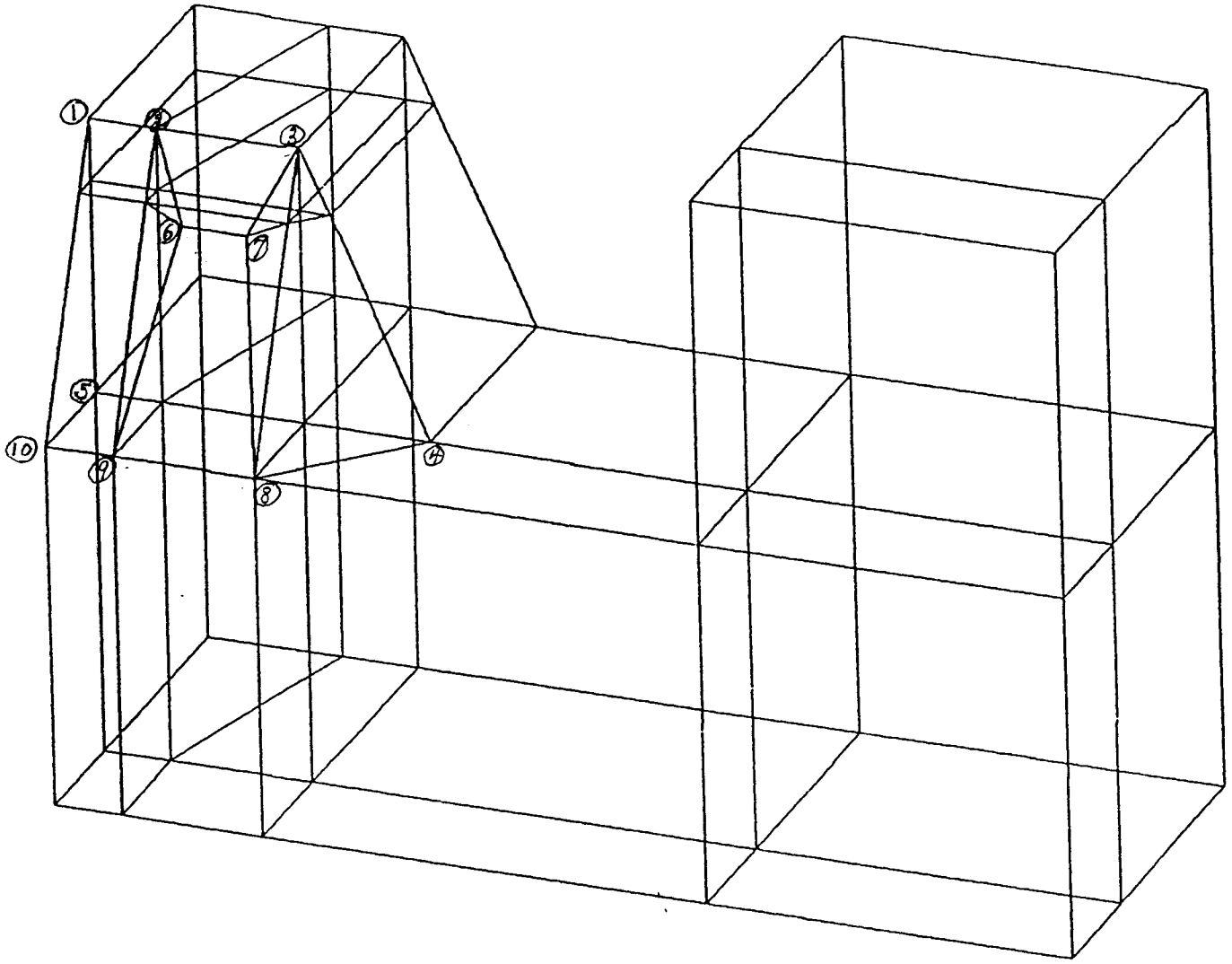


THE FOLLOWING IS A MAP OF BX/BY IN (KG) OF PROBLEM

| ->X(UN)= | 0.000 | 1.000 | 2.000 | 3.000 | 4.000 | 5.000 | 6.000 | 7.000 | 8.000 | 9.000 | 10.000 | 11.000 | 12.000 | 13.000 | 14.000 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ->Y(UN)= | 10.500 | | | | | | | | | | | | | | |
| BX(KG)= | -.000 | .002 | .004 | .008 | .015 | .028 | .043 | .053 | .057 | .054 | .039 | .018 | .007 | .006 | .005 |
| BY(KG)= | .003 | .004 | .005 | .009 | .014 | .018 | .016 | .009 | -.000 | -.012 | -.022 | -.020 | -.010 | -.004 | -.004 |
| ->Y(UN)= | 9.750 | | | | | | | | | | | | | | |
| BX(KG)= | 0.000 | 4.291 | 8.884 | 12.423 | 14.730 | 15.855 | 16.335 | 16.607 | 16.736 | 16.700 | 16.353 | 15.254 | 11.964 | .008 | .005 |
| BY(KG)= | 2.059 | 2.055 | 2.026 | 1.321 | .714 | .297 | .245 | .101 | .023 | -.097 | -.379 | -1.048 | -3.892 | -.004 | -.006 |
| ->Y(UN)= | 9.000 | | | | | | | | | | | | | | |
| BX(KG)= | 0.000 | 4.306 | 8.791 | 12.091 | 14.358 | 15.732 | 16.299 | 16.606 | 16.733 | 16.671 | 16.166 | 14.880 | 12.044 | 10.454 | .005 |
| BY(KG)= | 5.401 | 5.391 | 5.187 | 3.507 | 1.887 | .758 | .576 | .252 | .057 | -.242 | -.887 | -2.669 | -6.916 | -10.124 | -.009 |
| ->Y(UN)= | 8.250 | | | | | | | | | | | | | | |
| BX(KG)= | 0.000 | 4.379 | 7.926 | 11.391 | 14.287 | 15.742 | 16.339 | 16.630 | 16.766 | 16.716 | 16.184 | 15.326 | 11.767 | 10.071 | 5.332 |
| BY(KG)= | 8.748 | 8.803 | 7.715 | 5.844 | 3.210 | 1.279 | .915 | .408 | .084 | -.412 | -1.516 | -4.616 | -8.727 | -10.517 | -9.894 |
| ->Y(UN)= | 7.500 | | | | | | | | | | | | | | |
| BX(KG)= | 0.000 | 3.365 | 6.641 | 10.465 | 13.809 | 15.773 | 16.322 | 16.650 | 16.803 | 16.766 | 16.254 | 13.799 | 10.637 | 8.297 | 3.725 |
| BY(KG)= | 11.801 | 12.102 | 10.423 | 9.156 | 4.989 | 1.861 | 1.161 | .566 | .126 | -.557 | -2.232 | -7.007 | -10.392 | -11.667 | -11.235 |
| ->Y(UN)= | 6.750 | | | | | | | | | | | | | | |
| BX(KG)= | 0.000 | 2.446 | 4.973 | 8.505 | 12.412 | 15.676 | 16.299 | 16.682 | 16.811 | 16.681 | 16.169 | 12.282 | 7.905 | 4.880 | 2.318 |
| BY(KG)= | 13.974 | 14.162 | 12.891 | 12.016 | 7.632 | 2.545 | 1.541 | .759 | .152 | -.687 | -3.169 | -9.430 | -13.120 | -13.655 | -14.227 |
| ->Y(UN)= | 6.000 | | | | | | | | | | | | | | |
| BX(KG)= | 0.000 | 1.628 | 3.309 | 5.873 | 9.591 | 13.117 | 17.315 | 17.188 | 17.797 | 18.256 | 17.579 | 8.132 | 4.056 | 2.221 | .973 |
| BY(KG)= | 15.496 | 15.572 | 14.809 | 14.395 | 11.313 | 2.943 | 1.111 | .641 | .662 | -.249 | -7.201 | -13.588 | -15.613 | -15.477 | -15.763 |
| ->Y(UN)= | 5.250 | | | | | | | | | | | | | | |
| BX(KG)= | 0.000 | 1.180 | 2.584 | 3.947 | 6.618 | 7.236 | .052 | .074 | .069 | .079 | 2.506 | 2.799 | 1.649 | .990 | .296 |
| BY(KG)= | 16.664 | 16.454 | 16.217 | 15.826 | 16.903 | 15.037 | 1.263 | 1.179 | .765 | .185 | -16.079 | -17.582 | -16.469 | -16.474 | -16.470 |
| ->Y(UN)= | 4.500 | | | | | | | | | | | | | | |
| BX(KG)= | 0.000 | .993 | 2.131 | 3.248 | 4.875 | -1.370 | -.639 | -.300 | -.162 | -.069 | .043 | .792 | .825 | .513 | .230 |
| BY(KG)= | 17.398 | 17.354 | 17.197 | 16.939 | 17.746 | 1.224 | 1.486 | 1.252 | .828 | .181 | -17.719 | -17.469 | -16.821 | -16.755 | -16.762 |
| ->Y(UN)= | 3.750 | | | | | | | | | | | | | | |
| BX(KG)= | 0.000 | .909 | 1.965 | 3.145 | 4.290 | -2.138 | -1.332 | -.774 | -.526 | -.378 | -.366 | .598 | .257 | .212 | .099 |
| BY(KG)= | 18.128 | 18.106 | 18.021 | 18.046 | 18.367 | 1.991 | 1.615 | 1.462 | .943 | .233 | -17.786 | -16.882 | -16.950 | -16.898 | -16.879 |
| ->Y(UN)= | 3.000 | | | | | | | | | | | | | | |
| BX(KG)= | 0.000 | .617 | 1.402 | 2.390 | 3.366 | -2.713 | -1.864 | -1.189 | -.871 | -.684 | -.524 | -.197 | -.092 | -.052 | -.017 |
| BY(KG)= | 18.719 | 18.731 | 18.747 | 18.974 | 18.889 | 2.815 | 2.446 | 1.744 | 1.099 | .288 | -17.204 | -17.059 | -16.981 | -16.932 | -16.913 |
| ->Y(UN)= | 2.250 | | | | | | | | | | | | | | |
| BX(KG)= | 0.000 | .087 | .364 | 1.102 | -2.970 | -3.038 | -1.918 | -1.362 | -1.001 | -.857 | -.766 | -.567 | -.360 | -.204 | -.093 |
| BY(KG)= | 19.037 | 19.098 | 19.334 | 19.666 | 3.276 | 3.813 | 3.038 | 2.102 | 1.272 | .362 | -16.862 | -16.884 | -16.895 | -16.864 | -16.857 |
| ->Y(UN)= | 1.500 | | | | | | | | | | | | | | |
| BX(KG)= | 0.000 | -1.517 | -2.911 | -3.473 | -5.635 | -2.859 | -1.868 | -1.404 | -1.107 | -.974 | -.842 | -.633 | -.417 | -.261 | -.122 |
| BY(KG)= | 18.360 | 18.771 | 19.173 | 20.357 | 5.751 | 4.942 | 3.642 | 2.380 | 1.443 | .433 | -16.720 | -16.734 | -16.759 | -16.757 | -16.761 |
| ->Y(UN)= | .750 | | | | | | | | | | | | | | |
| BX(KG)= | .000 | -.023 | -.072 | -4.519 | -3.473 | -1.781 | -1.207 | -.923 | -.771 | -.682 | -.577 | -.410 | -.287 | -.180 | -.066 |
| BY(KG)= | 17.307 | 17.294 | 17.296 | 17.323 | 8.694 | 5.793 | 3.689 | 2.637 | 1.541 | .585 | -16.529 | -16.545 | -16.631 | -16.651 | -16.668 |
| ->Y(UN)= | 0.000 | | | | | | | | | | | | | | |
| BX(KG)= | .000 | -.000 | -.000 | .001 | .002 | -.001 | .000 | -.000 | -.000 | -.000 | -.036 | -.027 | -.019 | -.011 | -.006 |
| BY(KG)= | 17.300 | 17.283 | 17.147 | 15.075 | 9.620 | 6.131 | 4.139 | 2.715 | 1.584 | .614 | -16.471 | -16.539 | -16.580 | -16.613 | -16.627 |

THE FOLLOWING IS A MAP OF BX/BY IN (KG) OF PROBLEM

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ->X(UN)= | 0.000 | 1.000 | 2.000 | 3.000 | 4.000 | 5.000 | 6.000 | 7.000 | 8.000 | 9.000 | 10.000 | 11.000 | 12.000 | 13.000 | 14.000 |
| ->Y(UN)= | 10.500 | | | | | | | | | | | | | | |
| BX(KG)= | -.000 | .002 | .004 | .008 | .015 | .028 | .043 | .053 | .057 | .054 | .039 | .018 | .007 | .006 | .005 |
| BY(KG)= | .003 | .004 | .005 | .009 | .014 | .018 | .016 | .009 | -.000 | -.012 | -.022 | -.020 | -.010 | -.004 | -.004 |
| ->Y(UN)= | 9.750 | | | | | | | | | | | | | | |
| BX(KG)= | 0.000 | 4.291 | 8.884 | 12.423 | 14.730 | 15.855 | 16.335 | 16.607 | 16.736 | 16.700 | 16.353 | 15.254 | 11.964 | .008 | .005 |
| BY(KG)= | 2.059 | 2.055 | 2.026 | 1.321 | .714 | .297 | .245 | .101 | .023 | -.097 | -.379 | -1.048 | -3.892 | -.004 | -.006 |
| ->Y(UN)= | 9.000 | | | | | | | | | | | | | | |
| BX(KG)= | 0.000 | 4.306 | 8.791 | 12.091 | 14.558 | 15.732 | 16.299 | 16.606 | 16.733 | 16.671 | 16.166 | 14.880 | 12.044 | 10.454 | .004 |
| BY(KG)= | 5.401 | 5.391 | 5.187 | 3.507 | 1.887 | .758 | .576 | .252 | .057 | -.242 | -.887 | -2.669 | -6.916 | -10.124 | -.009 |
| ->Y(UN)= | 8.250 | | | | | | | | | | | | | | |
| BX(KG)= | 0.000 | 4.379 | 7.926 | 11.391 | 14.287 | 15.745 | 16.339 | 16.630 | 16.766 | 16.716 | 16.184 | 14.526 | 11.767 | 10.071 | 9.332 |
| BY(KG)= | 8.748 | 8.803 | 7.715 | 5.844 | 3.210 | 1.279 | .915 | .408 | .084 | -.412 | -1.516 | -4.616 | -8.727 | -10.517 | -9.894 |
| ->Y(UN)= | 7.500 | | | | | | | | | | | | | | |
| BX(KG)= | 0.000 | 3.365 | 6.641 | 10.465 | 13.809 | 15.773 | 16.322 | 16.650 | 16.803 | 16.766 | 16.254 | 13.799 | 10.837 | 8.292 | 5.725 |
| BY(KG)= | 11.801 | 12.102 | 10.423 | 9.156 | 4.989 | 1.861 | 1.161 | .566 | .126 | -.557 | -2.232 | -7.007 | -10.392 | -11.667 | -11.235 |
| ->Y(UN)= | 6.750 | | | | | | | | | | | | | | |
| BX(KG)= | 0.000 | 2.446 | 4.975 | 8.505 | 12.412 | 15.656 | 16.299 | 16.682 | 16.811 | 16.681 | 16.169 | 12.282 | 7.905 | 4.880 | 2.318 |
| BY(KG)= | 13.974 | 14.162 | 12.891 | 12.016 | 7.632 | 2.545 | 1.541 | .739 | .152 | -.687 | -3.169 | -9.930 | -13.120 | -13.655 | -14.227 |
| ->Y(UN)= | 6.000 | | | | | | | | | | | | | | |
| BX(KG)= | 0.000 | 1.638 | 3.309 | 5.873 | 9.591 | 18.117 | 17.415 | 17.138 | 17.797 | 18.256 | 17.579 | 8.152 | 4.056 | 2.251 | .973 |
| BY(KG)= | 15.496 | 15.572 | 14.809 | 14.395 | 11.313 | 2.943 | 1.111 | .941 | .662 | -.249 | -7.201 | -13.588 | -15.613 | -15.477 | -15.763 |
| ->Y(UN)= | 5.250 | | | | | | | | | | | | | | |
| BX(KG)= | 0.000 | 1.180 | 2.584 | 3.947 | 6.618 | 7.334 | .053 | .074 | .069 | .079 | 3.506 | 2.799 | 1.649 | .990 | .296 |
| BY(KG)= | 16.664 | 16.454 | 16.217 | 15.826 | 16.903 | 15.837 | 1.293 | 1.179 | .765 | .185 | -19.079 | -17.582 | -16.469 | -16.474 | -16.470 |
| ->Y(UN)= | 4.500 | | | | | | | | | | | | | | |
| BX(KG)= | 0.000 | .993 | 2.131 | 3.248 | 4.875 | -1.370 | -.639 | -.300 | -.163 | -.069 | .043 | .792 | .824 | .513 | .230 |
| BY(KG)= | 17.398 | 17.354 | 17.197 | 16.939 | 17.746 | 1.224 | 1.486 | 1.252 | .828 | .181 | -17.719 | -17.469 | -16.821 | -16.755 | -16.762 |
| ->Y(UN)= | 3.750 | | | | | | | | | | | | | | |
| BX(KG)= | 0.000 | .909 | 1.965 | 3.145 | 4.290 | -2.138 | -1.332 | -.774 | -.526 | -.378 | -.366 | .598 | .357 | .212 | .099 |
| BY(KG)= | 18.128 | 18.106 | 18.021 | 18.046 | 18.367 | 1.991 | 1.915 | 1.462 | .943 | .233 | -17.786 | -16.882 | -16.950 | -16.898 | -16.879 |
| ->Y(UN)= | 3.000 | | | | | | | | | | | | | | |
| BX(KG)= | 0.000 | .617 | 1.402 | 2.390 | 3.366 | -2.713 | -1.884 | -1.189 | -.871 | -.684 | -.524 | -.197 | -.092 | -.042 | -.017 |
| BY(KG)= | 18.719 | 18.731 | 18.747 | 18.974 | 18.989 | 2.815 | 2.446 | 1.744 | 1.099 | .288 | -17.204 | -17.059 | -16.981 | -16.932 | -16.913 |
| ->Y(UN)= | 2.250 | | | | | | | | | | | | | | |
| BX(KG)= | 0.000 | .087 | .364 | 1.102 | -4.970 | -3.038 | -1.918 | -1.362 | -1.001 | -.852 | -.786 | -.567 | -.340 | -.204 | -.093 |
| BY(KG)= | 19.037 | 19.098 | 19.334 | 19.666 | 3.276 | 3.813 | 3.038 | 2.102 | 1.272 | .362 | -16.862 | -16.884 | -16.895 | -16.864 | -16.857 |
| ->Y(UN)= | 1.500 | | | | | | | | | | | | | | |
| BX(KG)= | 0.000 | -1.517 | -2.911 | -3.473 | -5.435 | -2.859 | -1.868 | -1.404 | -1.107 | -.974 | -.842 | -.633 | -.417 | -.261 | -.122 |
| BY(KG)= | 18.560 | 18.771 | 19.173 | 20.357 | 5.751 | 4.942 | 3.642 | 2.380 | 1.443 | .433 | -16.720 | -16.734 | -16.759 | -16.757 | -16.761 |
| ->Y(UN)= | .750 | | | | | | | | | | | | | | |
| BX(KG)= | .000 | -.023 | -.072 | -4.519 | -3.473 | -1.781 | -1.207 | -.923 | -.771 | -.682 | -.577 | -.410 | -.287 | -.180 | -.066 |
| BY(KG)= | 17.307 | 17.299 | 17.296 | 17.323 | 8.694 | 5.793 | 3.989 | 2.637 | 1.541 | .585 | -16.529 | -16.595 | -16.631 | -16.651 | -16.668 |
| ->Y(UN)= | 0.000 | | | | | | | | | | | | | | |
| BX(KG)= | .000 | -.000 | -.000 | .001 | .002 | -.001 | .000 | -.000 | -.000 | -.000 | -.036 | -.027 | -.019 | -.011 | -.004 |
| BY(KG)= | 17.300 | 17.283 | 17.147 | 15.075 | 9.620 | 6.151 | 4.139 | 2.715 | 1.584 | .614 | -16.471 | -16.539 | -16.580 | -16.613 | -16.627 |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