ANL-HEP-TR-96-14

Experiences with Stacking the First Four ATLAS Submodules at Argonne

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22 February 1996

Purpose

This note is to review our experience at Argonne with assembling the first four submodules constructed at this location. We will try to cover all of the experiences, and at the end add some comments about changes that were incorporated into the current modules, and suggested changes that may be incorporated into future modules.

Plate Measurement

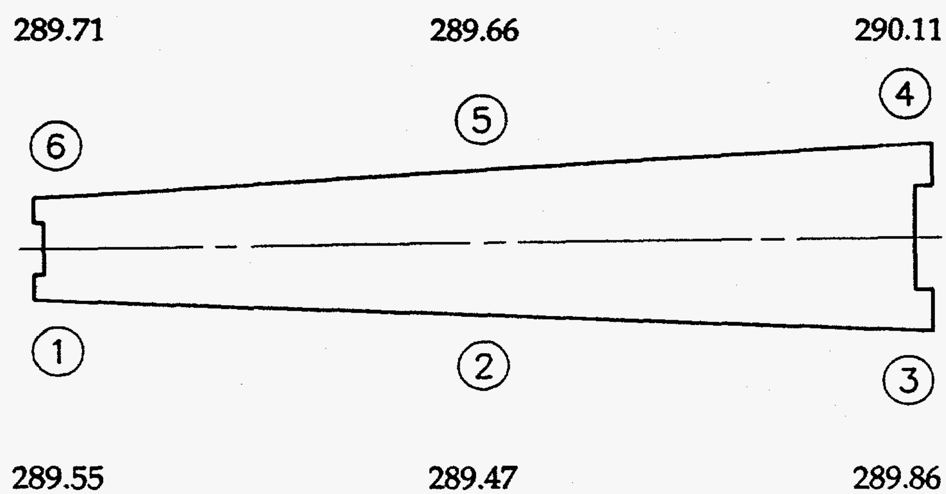
The plates, as received from the stamper, were each measured for thickness. These numbers were then added to calculate the average thickness that would predict the overall stack height. In reality, the control of the stack height is more a function of the plate flatness than the thickness. Figure 1 shows the thickness distribution of the raw plates and plates after finishing.

Plate Cleaning

All of the plates were cleaned using a perchlorethylene degreaser owned by Argonne Central Shops. This degreaser is being phased out in the near future and will be replaced with a more environmentally friendly detergent bath facility. This degreaser was very effective in removing all of the oil on the plates, but it was still necessary to hand wipe the plates before stacking them, to remove some residual particulates. It is suggested that the detergent wash will prove to be better, since the bath has an agitating spray head that will flood the plates much the same as a domestic dishwasher. This facility will also incorporate a dryer that will assure that the plates will be thoroughly dried and less prone to oxidization when finished.

Dry Stack

The first stamped masterplates that had been surfaced with the "Time Saver" process were individually measured after cleaning, and then stacked and compressed using the stacking fixture. This stack was measured after full compression to 50 ft. lbs. (68 Newton meters). The following table lists those measurements.



Gluing

Due to a delay in the procurement of the automatic equipment, it was decided that a manual method would be used for the application of glue in these first four submodules. In preparation for this, a set of templates were designed and fabricated specifically for this purpose. The standard pattern proposed by Lluis Miralles, and used on the first two submodules stacked at CERN in November, was modified slightly to attempt to reduce squeeze-out and eliminate the necessity for cleaning out the source holes. Special cartridges using the Ciba Giegy 2011 adhesive were packaged in dual dispensers and smaller nozzles were used to achieve better control of the deposition of the adhesive drops. In retrospect, this was probably not necessary since the standard twin tube dispensers, sold by many adhesive manufacturers including Ciba Giegy, are adequate. The amount of glue for the first two modules was set at .22 gm/drop. This was adjusted downward (.20 gm/drop) after small plate measurement errors were discovered.

Final Stacking of the Modules

The final stacking of the modules went well. We will reconstruct the stacking, starting with Submodule # 1 and cover each separately.

Submodule # 1

The stacking started at 8:05 am (Chicago time) and was completed at approximately 11:00 am. The gluing was accomplished using a manual application and the templates made at Argonne. The plates were hand wiped dry to remove any residual surface contamination. All of the plates were previously degreased in a perchlorethylene degreaser. The only problems encountered are listed separately with the solutions, where appropriate. The participants in this first stack were:

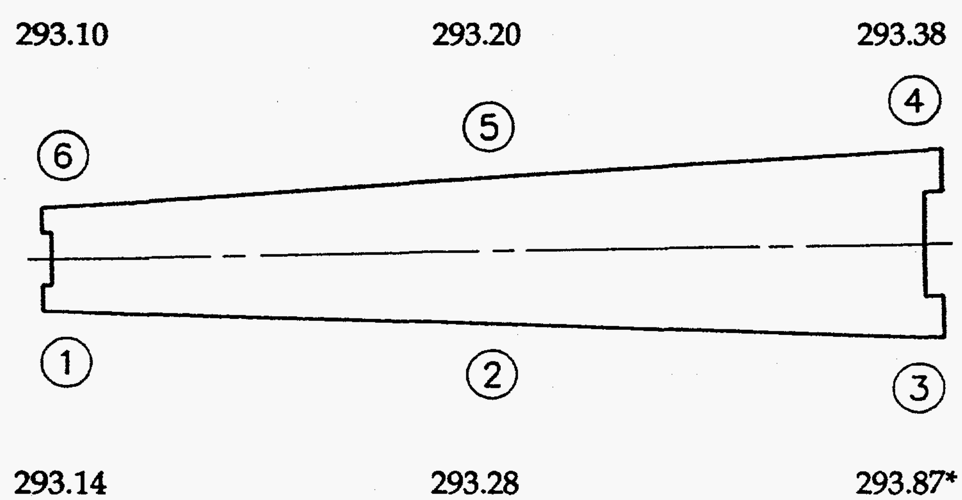
K. Wood and N. Hill -- Gluing and master plate handling
A. Caird -- Space plate preparation and spring pin insertion
J. Proudfoot -- Observing

1. Three people were used to stack, and one observed to check for errors as the stacking progressed. The first problem , which occurred soon after we started, was the dislocation of the small spacers at the narrow end. Magnets were used, but they were either too weak or too strong. The final solution was to use the strong magnets with the weld strap as a guide. This worked fairly well, but was not a perfect solution. Some spacers were dislocated, and had to be constantly checked to assure that they had not moved out of position.

2. Distorted plates caused the spring pins to push through into the scintillator slots and had to be watched to push them back before they were lodged in position and could not be moved. It is recommended that plates with short wave distortions not be used in the stack. Those plates were set aside and will not be used for the first four submodules.

3. The glue was obviously squeezing out into the scintillator slot at the large end of the module. A judgment reduction in the amount of glue used in that location was introduced.

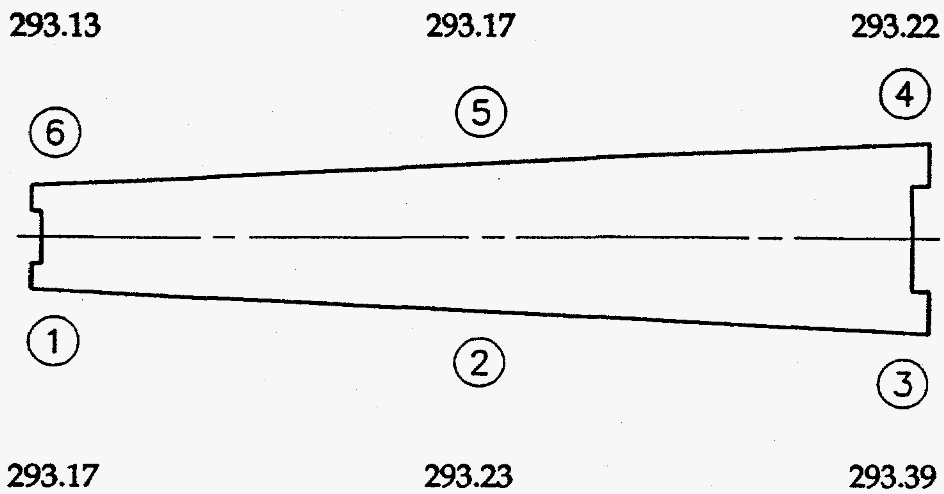
The stacking of this module went extremely well, other than the aforementioned problems. The three hour time allowance was adequate and no noticeable curing of the epoxy was apparent. The module was then allowed to cure until 10:00 am on the following day. The tack welding of the module was done at that time using the locating fixtures as designed. TIG weld tacks were used in this case. The first welds were made at the center of the stack and three welds applied to each bar. The locating brackets were then removed and the final two tacks made in each location. The module was then removed from the fixture, set on a separate table, and measured. The dimensions of the first module follow. The ends of the module directly adjacent to the weld bars was less (large end 293.01, 292.97) (small end 292.67, 292.74). This is attributed to the shrinkage of the weld bar after tack welding.



* High due to a warped spacer plate.

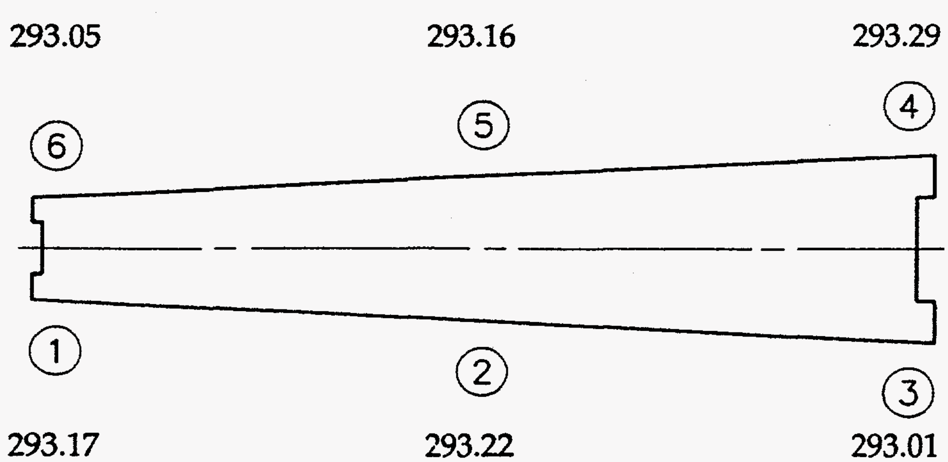
Submodule # 2

This submodule went as well as the first one, but more attention was paid to the plates that went into the stack. Obviously warped plates were replaced and set aside. This resulted in a slightly better stack, but the final results were much the same. The dimensions of this module are as follows. Again the ends of the module were less (large end 293.01, 292.50) (small end 292.92, 292.80).



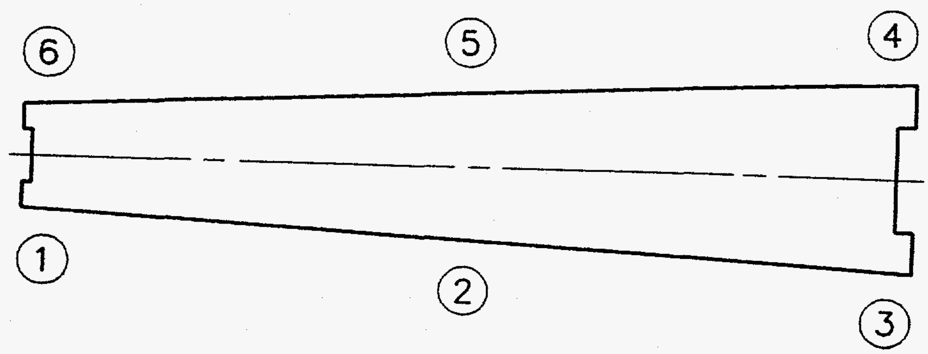
Submodule # 3

The masterplates were sorted before stacking to place the most out of flat plates in the middle of the stack. Prior to the stacking there was discussion about the positioning of the weld bars prior to tack welding the bars in place. It became apparent that this particular aspect of the locators had not been used either at CERN during the stacking of the two test modules or at Argonne during the stacking of the first two modules there. This was corrected and they were used on Modules 3 and 4. On the first two modules this was accomplished by shimming the bars in place both at the top and bottom (centered). Also due to an error in measurement of the plate thicknesses, that was attributed to a caliper that was out of calibration, we decided to reduce the amount of glue deposited to .2 grams per spot. The dimensions of Module # 3 follow. After tack welding this module, it was discovered that one of the weld bars at the small end had not been well placed in the inside corner. This weld bar was then ground loose, refitted then tack welded. There was no visible harm to the module as a result of this rework.



Submodule # 4

This module proceeded with no unique problems. The preliminary measurements are as follows:



Summary of Stacking Modules 1, 2, 3 and 4

	Module 1	Module 2	Module 3	Module 4	Crew
Cleaning	16 mhr	16 mhr	16 mhr	16 mhr	2 men
Stacking Time	10.8 mhr	9.25 mhr	8.5 mhr	7.75 mhr	3 men
Handling Time	6 mhr	6 mhr	6 mhr	6 mhr	2 men
Weld Time	4 mhr	3 mhr	3 mhr	3 mhr	1 man
Inspection	2 mhr	1.5 mhr	1.5 mhr	1.5 mhr	1 man
Prep. and Clean	16 hmr	16 hmr	16 hmr	16 hmr	2 men
Cortec	1 mhr	1 mhr	1 mhr	1 mhr	2 men
Packaging	2 mhr	2 mhr	2 mhr	2 mhr	1 man

Welding

Upon completion of the stacking of all four submodules, they were rigged for welding. A set of simple trunions were fabricated consisting of a plate bolted on the large and small ends of the module with a fixed trunion welded at the center point. The modules were set in stands which were originally developed for SDC. The stands allowed the welder to weld horizontally. The four outside welds were completed and the module was rotated and set with the plates in the horizontal position. The four inside welds were then made by down welding from the top. The first submodule was welded using TIG welds with filler wire on the outside welds and MIG on the inside welds. All subsequent modules were welded using TIG for all of the welds. The decision to use TIG was based upon the appearance of the welds and the fact that the MIG welds protruded beyond the surface of the bars. More practice may prove MIG welding to be a viable option. The welding and the work leading up to the final welding is covered as a separate subject. The MIG welding is somewhat faster and should be considered for production welding of the modules.

Measurement

The final measurement of the submodules are attached as Figs. 2 through 5. An analysis of these measurements is shown in Figs. 6-9, and the final position of the weld bars is shown in Figs. 10-12.

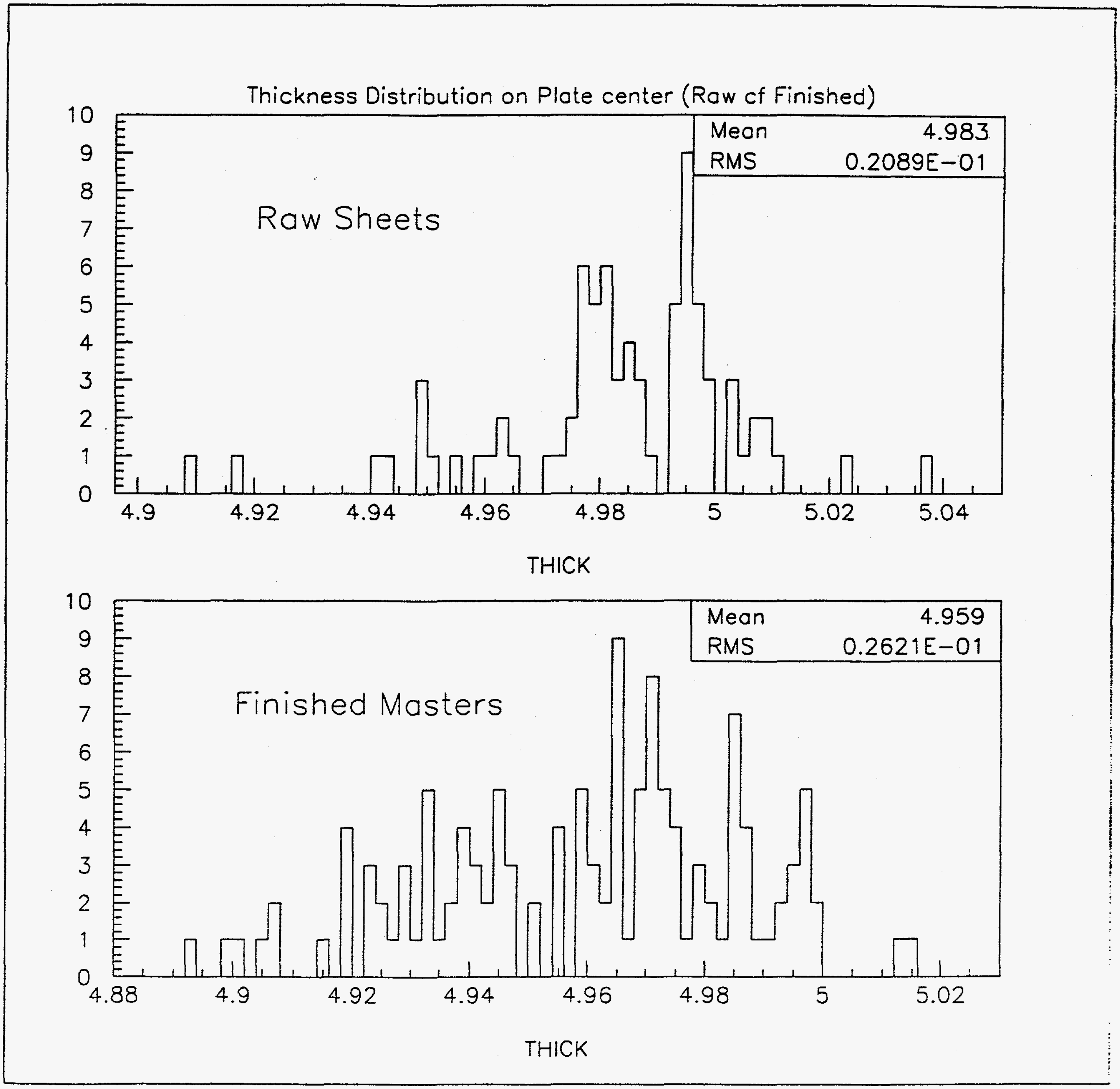

Thickness Distribution on Plate center (Raw cf Finished)
Raw Sheets
Mean 4.983
RMS 0.2089E-01
THICK
Finished Masters
Mean 4.959
RMS 0.2621E-01
THICK

Figure 1

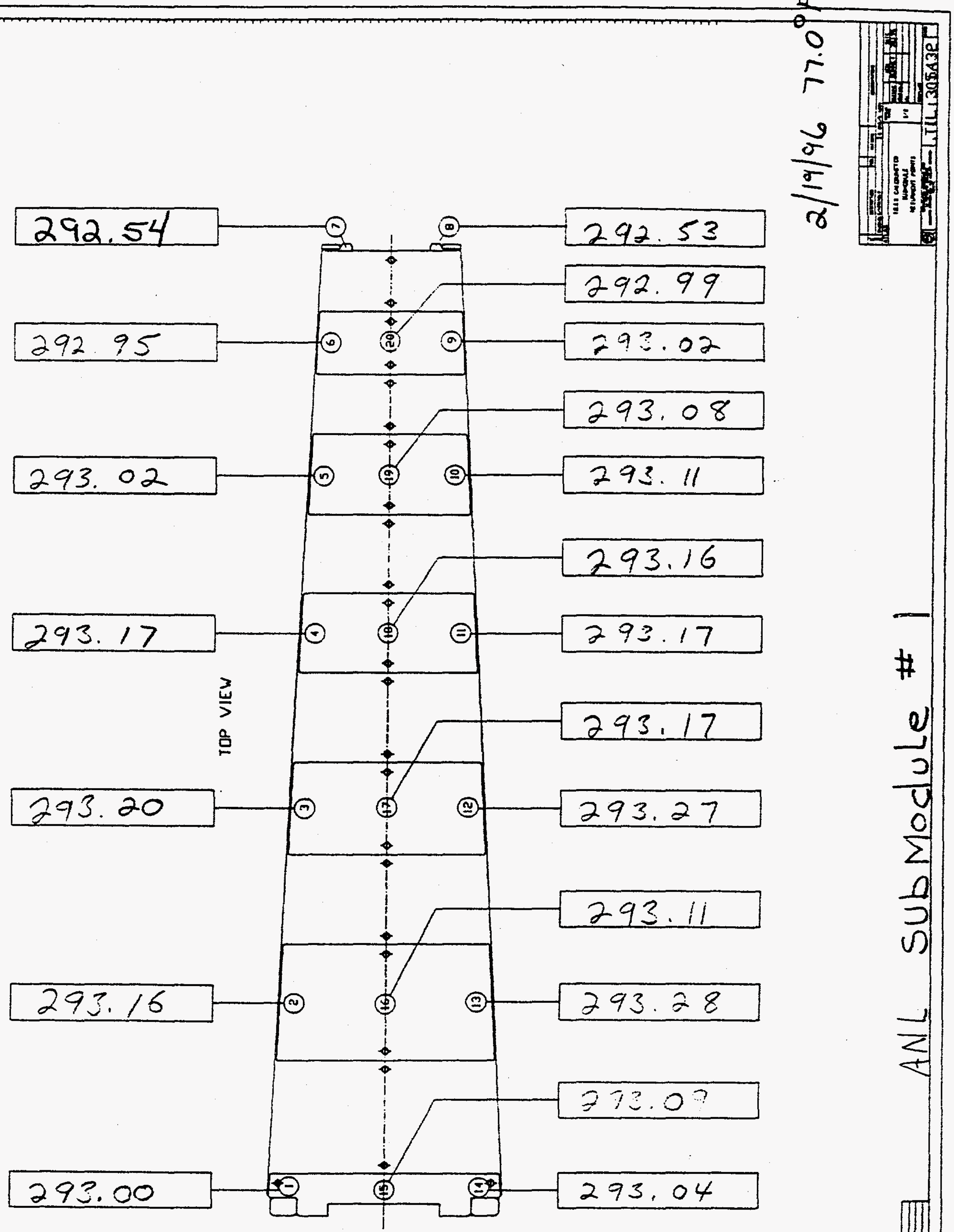

2/19/96 77.0°F
292.54
292.53
292.99
292.95
293.02
293.08
293.02
293.11
293.16
293.17
293.17
TOP VIEW
293.17
293.20
293.27
293.11
293.16
293.28
293.00
293.04
ANL SubModule # 1

Figure 2

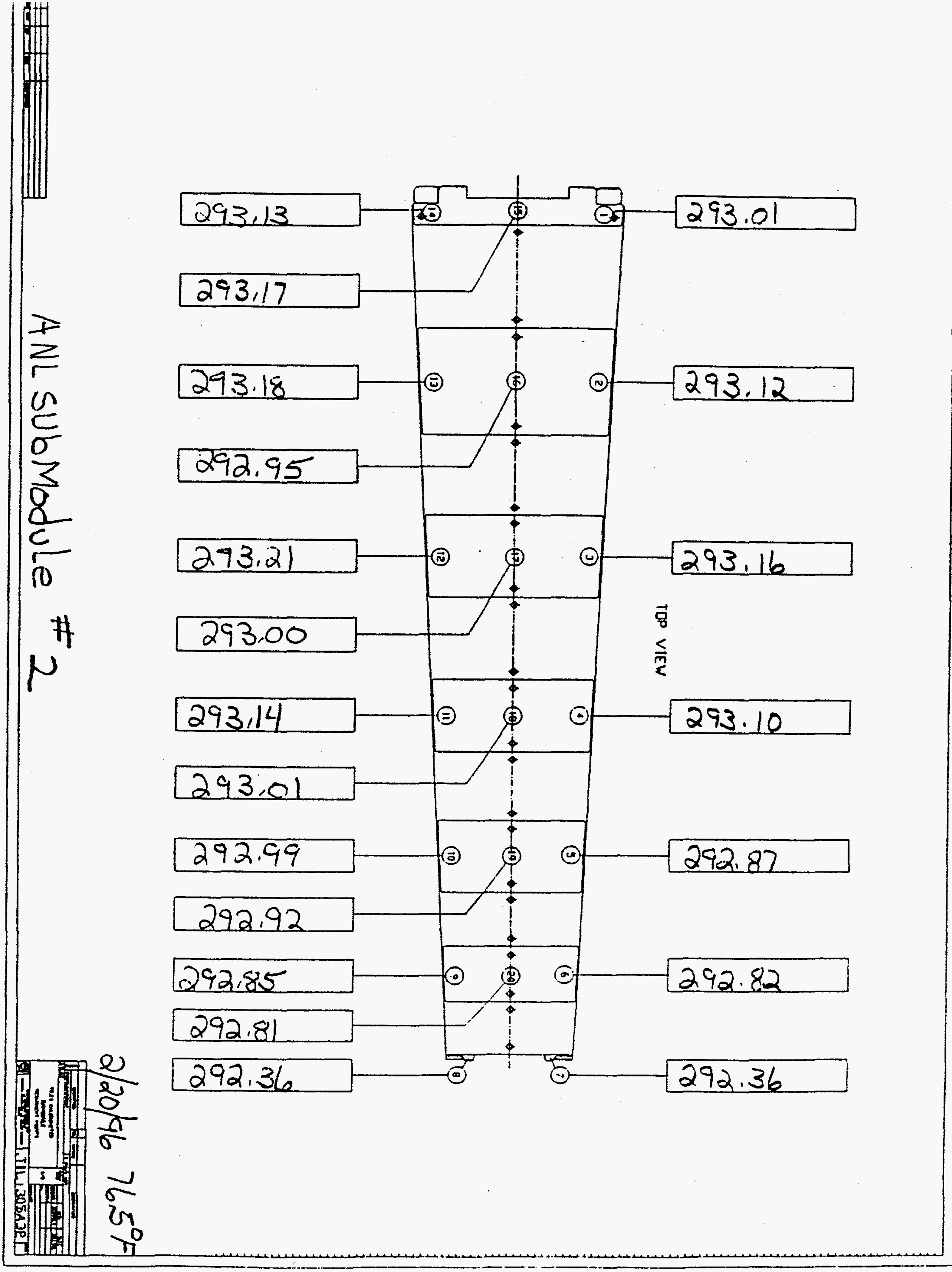

ANL SUbModule #2
2/20/96 76.5°F
TOP VIEW
293.13
293.01
293.17
293.18
293.12
292.95
293.21
293.16
293.00
293.14
293.10
293.01
292.99
292.87
292.92
292.85
292.82
292.81
292.36
292.36

Figure 3

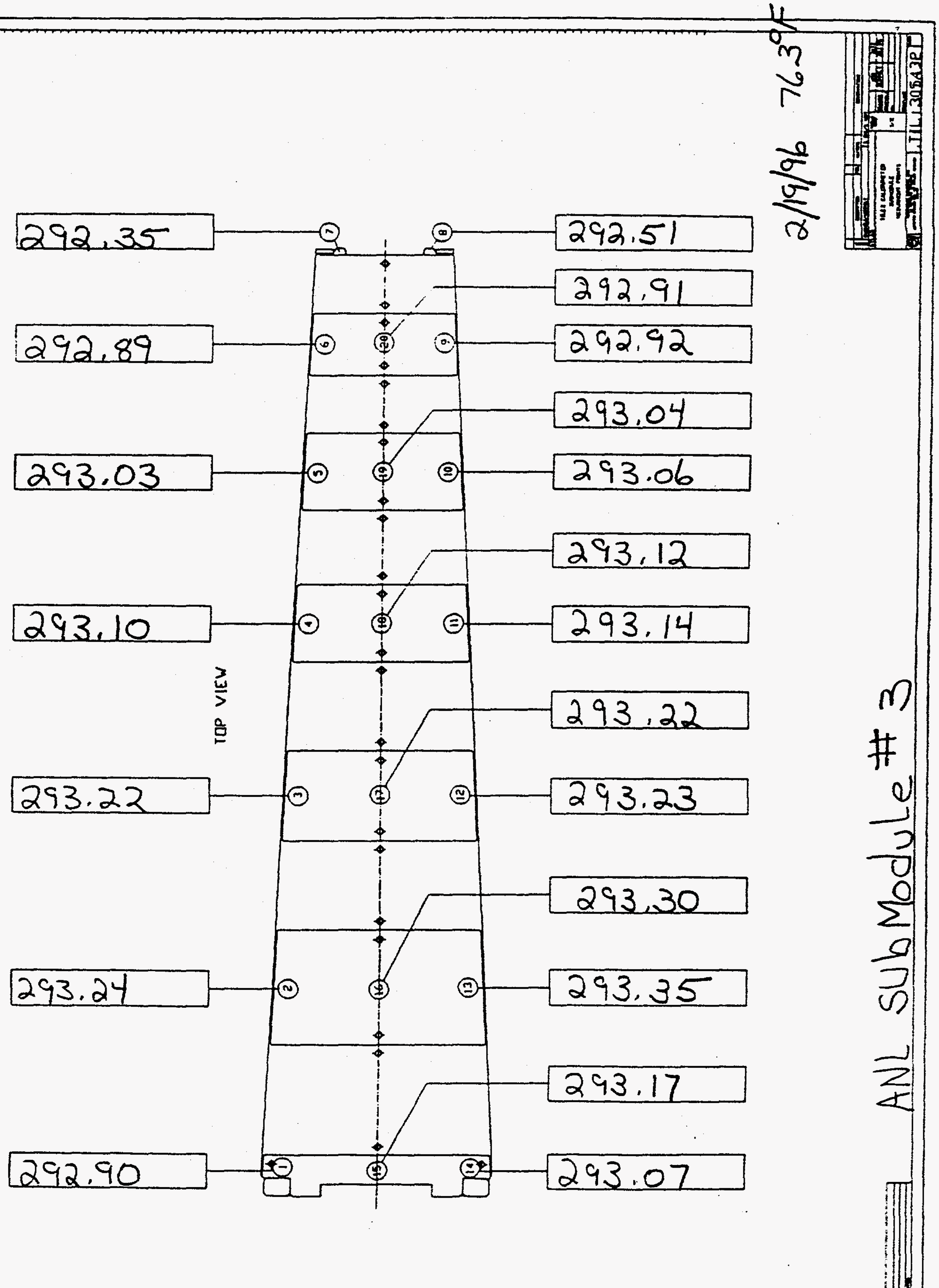
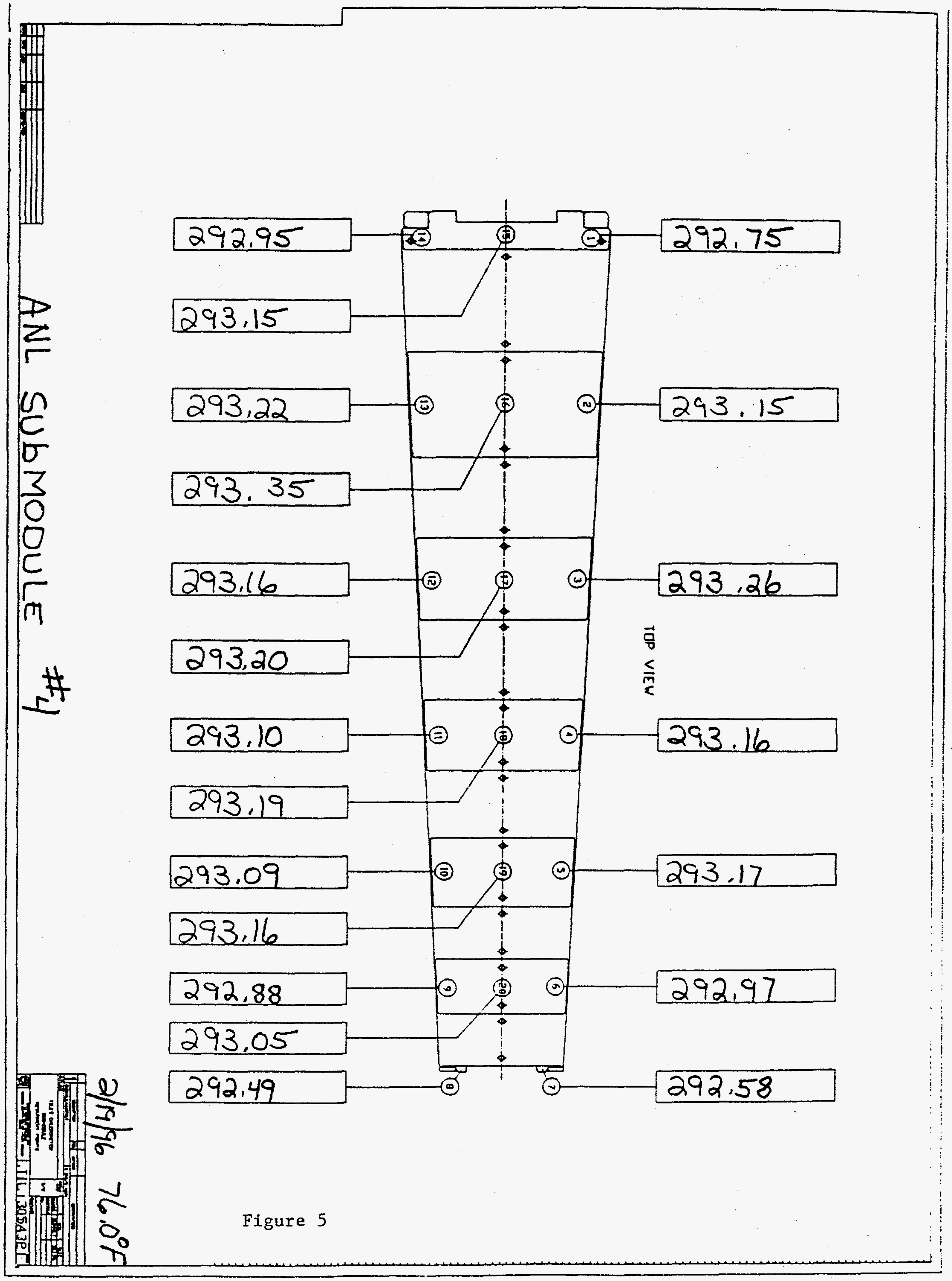

2/19/96 763°F
292.35
292.51
292.91
292.89
292.92
293.04
293.03
293.06
293.12
293.10
293.14
TOP VIEW
293.22
293.22
293.23
293.30
293.24
293.35
293.17
292.90
293.07
ANL SubModule #3

Figure 4



ANL SUBMODULE #4
TOP VIEW
292.95
292.75
293.15
293.22
293.15
293.35
293.16
293.26
293.20
293.10
293.16
293.19
293.09
293.17
293.16
292.88
292.97
293.05
292.49
292.58
76.0°F

Figure 5

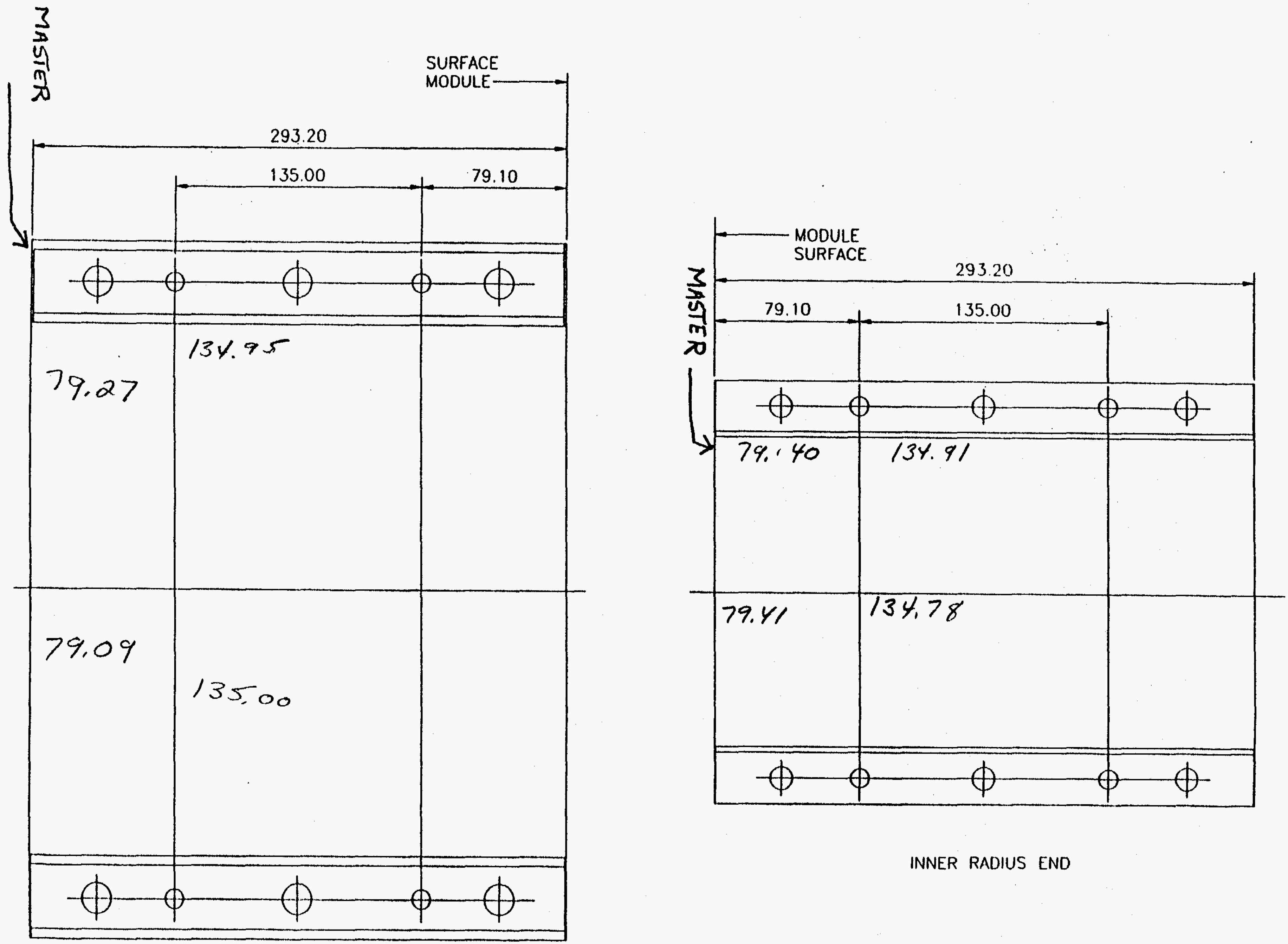


Figure 6

2/19/96 77.0°F

#1

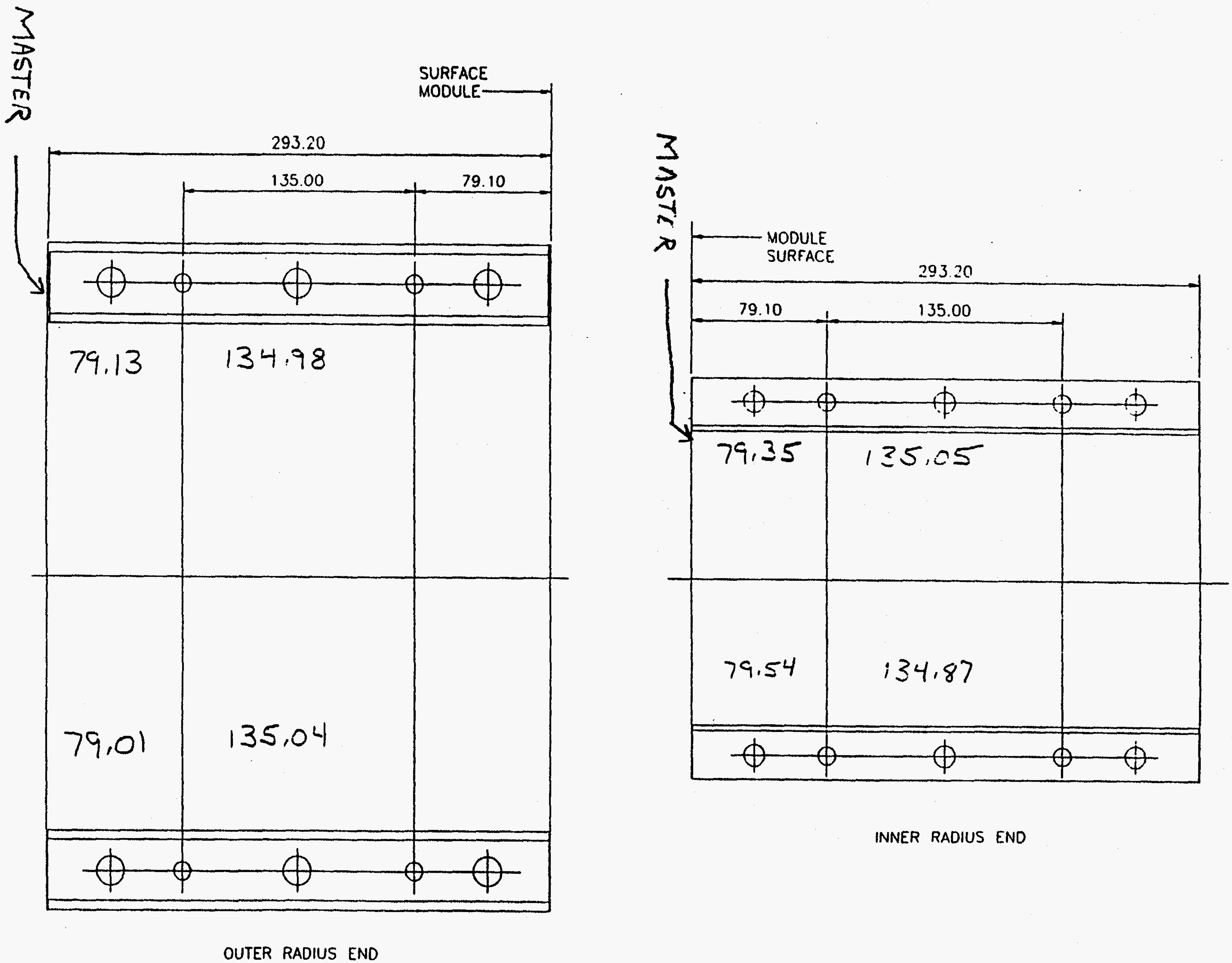


Figure 7

ANL subModule # 2

2/20/96 76.5°F

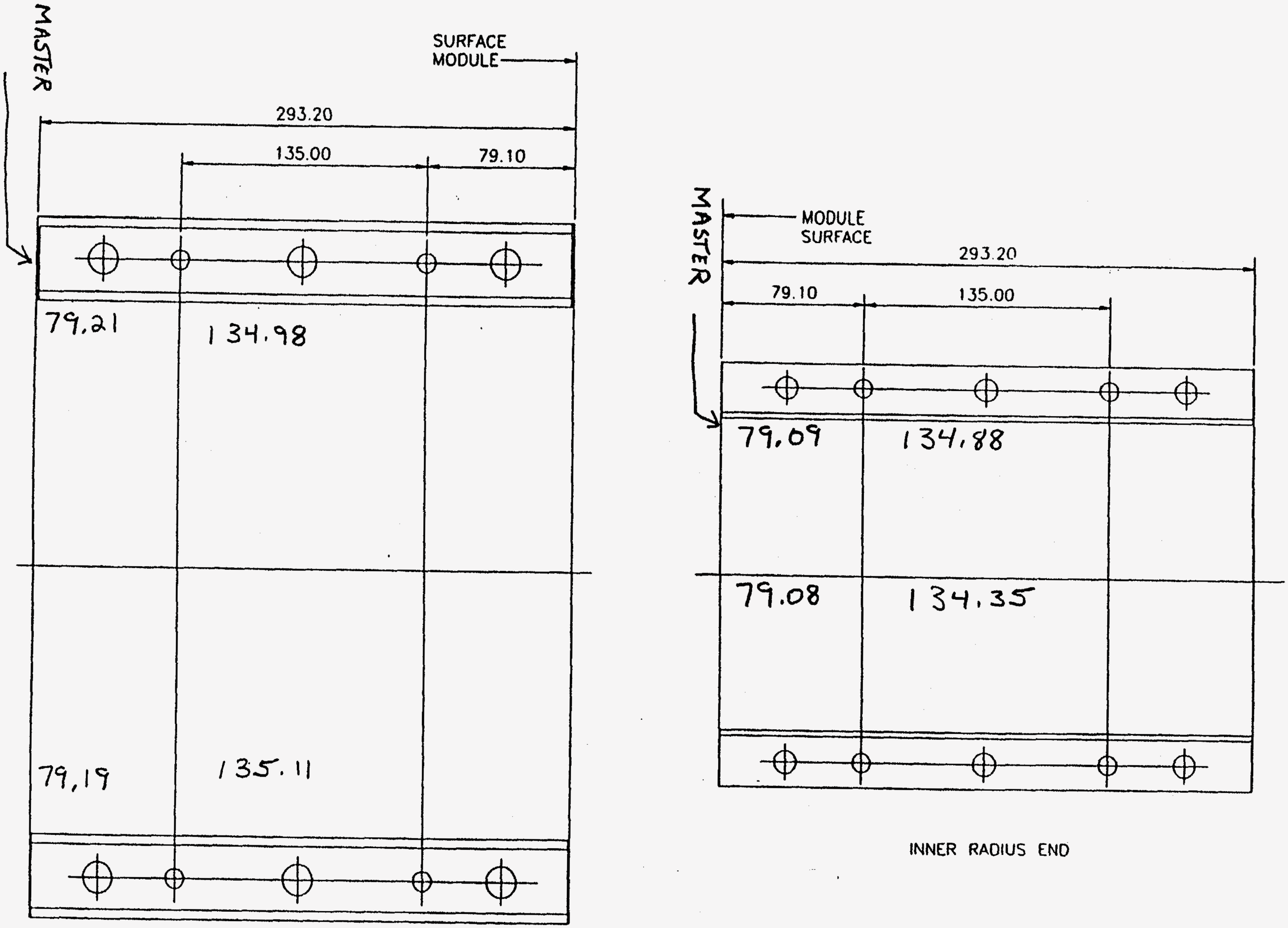

MASTER
SURFACE MODULE
293.20
135.00
79.10
79,21
134.98
79,19
135.11
OUTER RADIUS END
MASTER
MODULE SURFACE
293.20
79.10
135.00
79,09
134,88
79.08
134,35
INNER RADIUS END

Figure 8

ANL SubModule #2
2/19/96
71 °F

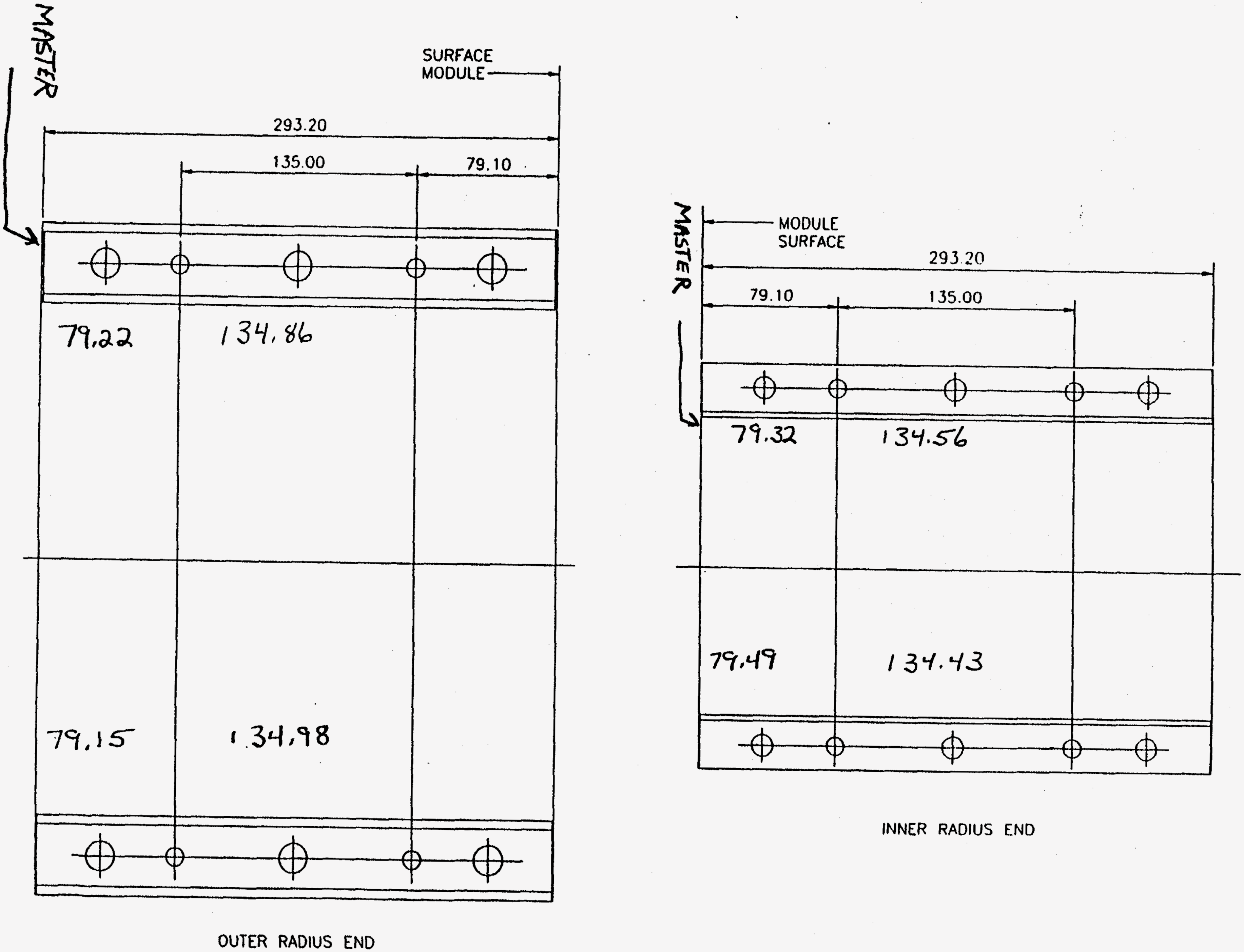
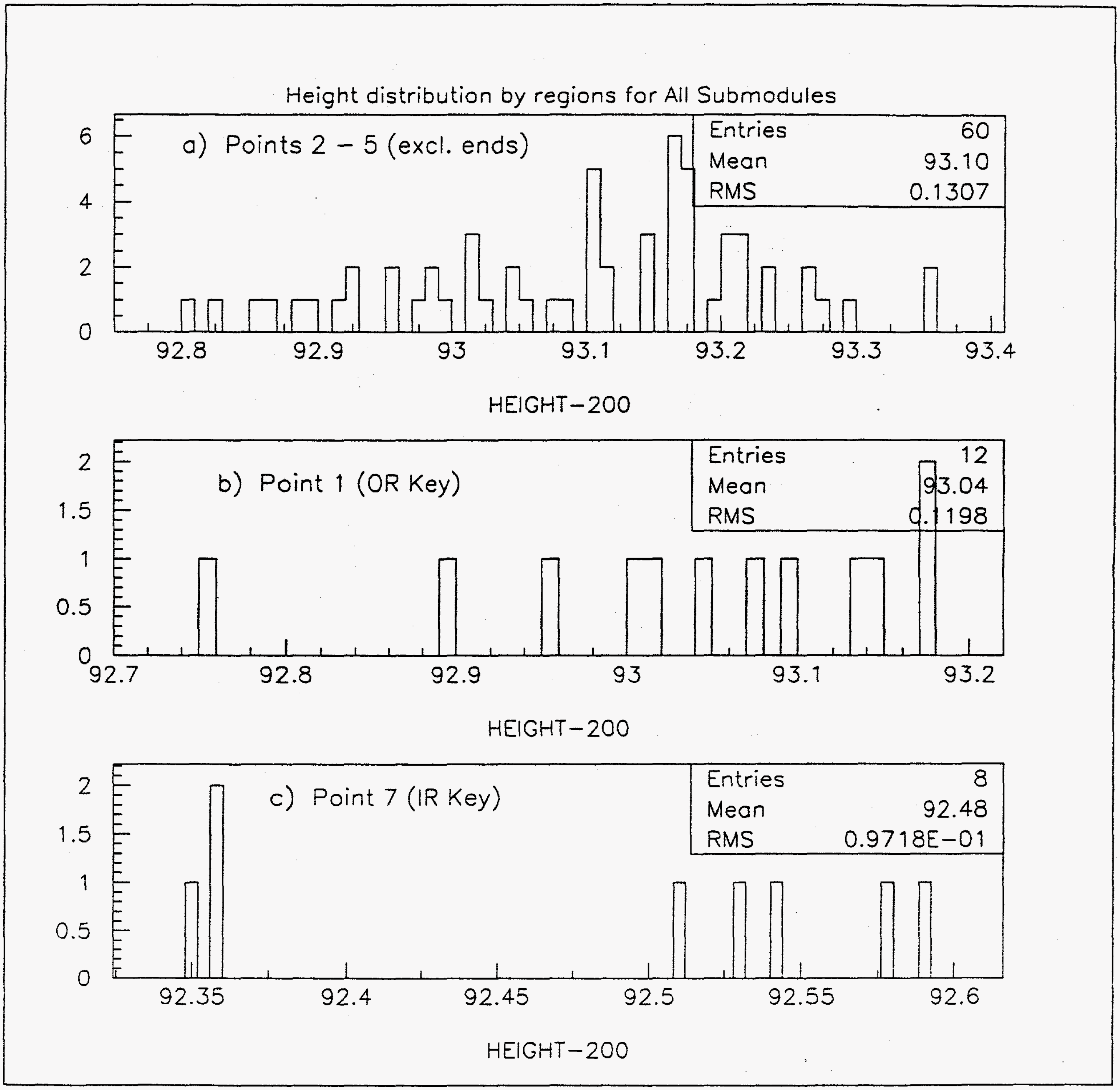


Figure 9

ANL SubModule #11 2/19/96 76.0°F



Height distribution by regions for All Submodules
a) Points 2 – 5 (excl. ends)
Entries 60
Mean 93.10
RMS 0.1307
HEIGHT–200
b) Point 1 (OR Key)
Entries 12
Mean 93.04
RMS 0.1198
HEIGHT–200
c) Point 7 (IR Key)
Entries 8
Mean 92.48
RMS 0.9718E–01
HEIGHT–200

Figure 10

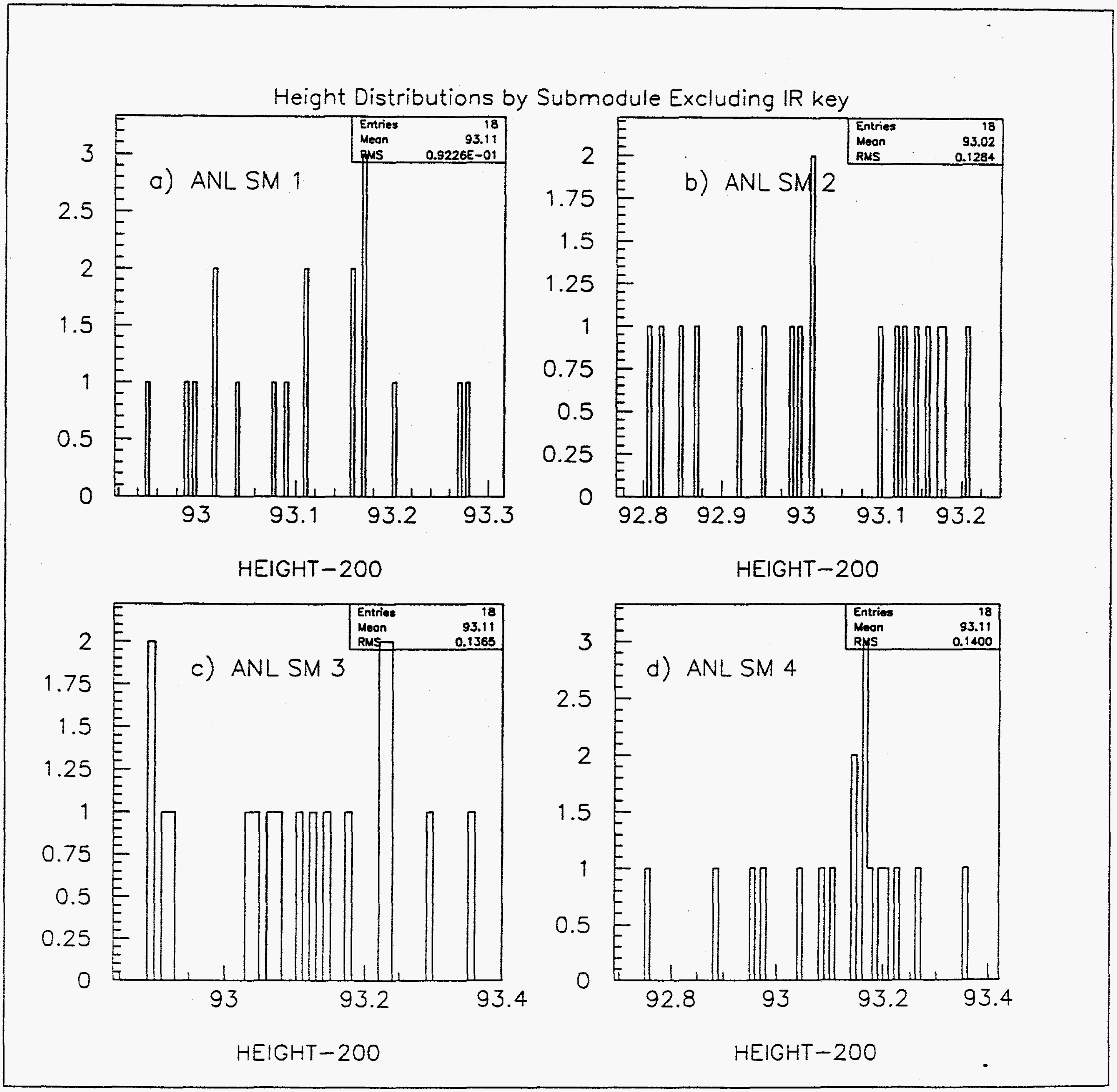

Height Distributions by Submodule Excluding IR key
a) ANL SM 1
Entries 18
Mean 93.11
RMS 0.9226E-01
b) ANL SM 2
Entries 18
Mean 93.02
RMS 0.1284
c) ANL SM 3
Entries 18
Mean 93.11
RMS 0.1365
d) ANL SM 4
Entries 18
Mean 93.11
RMS 0.1400
HEIGHT−200
HEIGHT−200
HEIGHT−200
HEIGHT−200

Figure 11

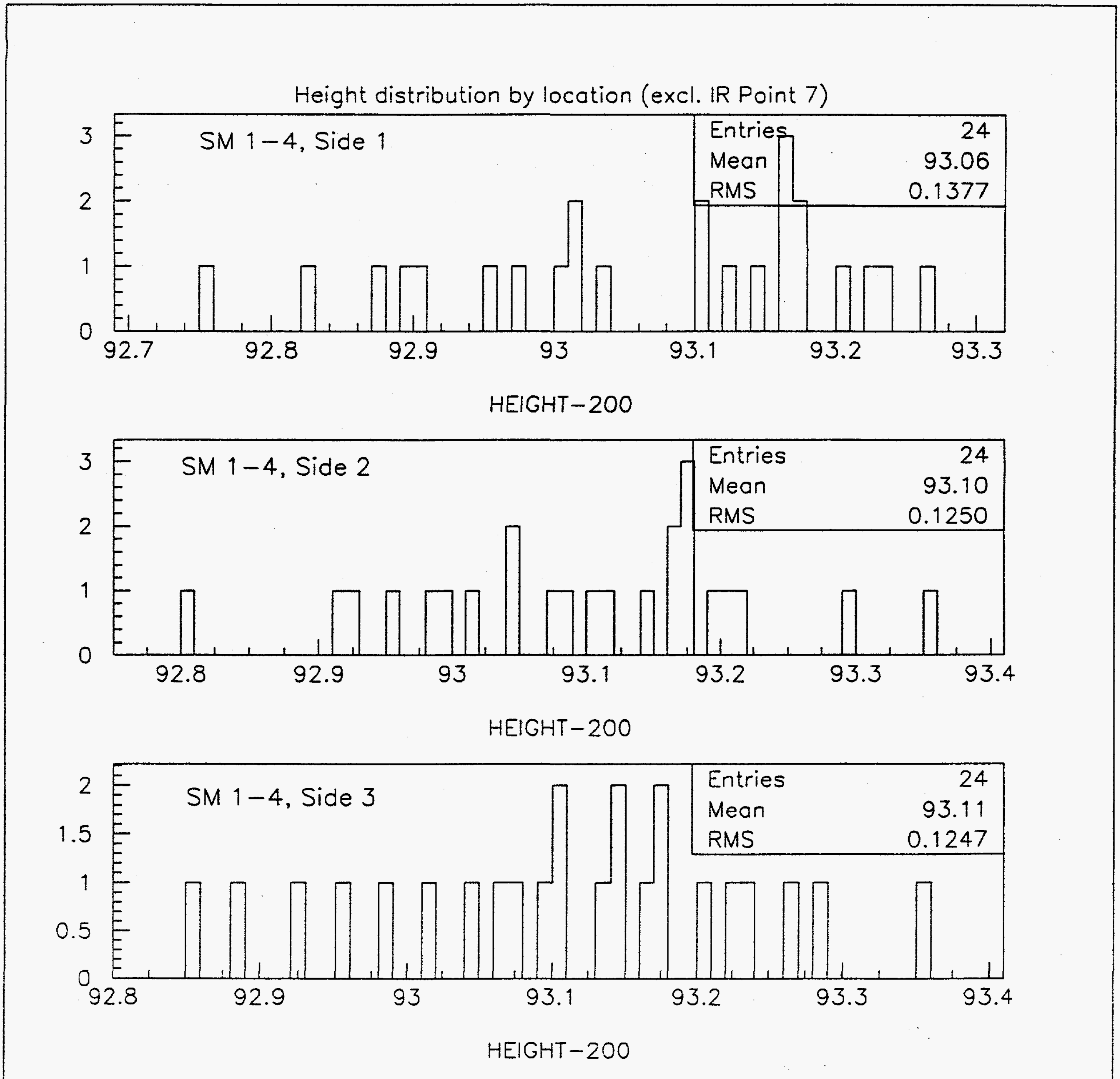

Height distribution by location (excl. IR Point 7)
SM 1−4, Side 1
Entries 24
Mean 93.06
RMS 0.1377
HEIGHT−200
SM 1−4, Side 2
Entries 24
Mean 93.10
RMS 0.1250
HEIGHT−200
SM 1−4, Side 3
Entries 24
Mean 93.11
RMS 0.1247
HEIGHT−200

Figure 12