1155 FLOOR LAYOUT HELPER

Instruction & Assistance in laying out floors in accordance with *ASTM E-1155*

1155 Helper

September 2011

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How to lay out a floor In Accordance with ASTM E-1155

General

When the traffic patterns across a floor are random (this is true on almost every floor) evaluation of the floor's flatness and levelness will necessarily involve a statistical sampling of the surface, since the infinite number of potential profiles cannot possibly be measured.

There are an infinite number of points on any floor, and there are an infinite number of directions you could walk across any of those points. Obviously, we can't measure every possible path.

Because we will use a statistical sampling process, we need to know **how to organize** the floor into conveniently-sized areas, **how much** data to collect and **where** and **how** to collect it. ASTM E-1155 tells us where to collect the data, how to collect the data, and how many samples we need.

What is the data we will collect?

"Flatness" is defined as the degree of similarity to a plane. "Levelness" is defined as being (at least locally) not tilted with respect to horizontal.

Flatness Measurement:

To measure the quality we call "Flatness," we'll measure and compare two adjacent 1-ft slopes. If the second 1-ft slope is identical to the first 1-ft slope, we'll say that the surface at that location is perfectly "flat." (It might not be “level”, but it is “flat” over that stretch) The amount of "Un-Flatness" depends on the degree to which the second 1-ft slope is different from the first. For example, if the first 1-ft slope goes uphill, and the second 1-ft slope goes downhill, then there is an obvious "bump" in the profile. If the first slope goes downhill and the second slope goes uphill, there is a "dip" in the profile at this point. The height of the bumps and dips will determine whether we call the profile "flat" or not. The Dipstick collects a 1-ft slope (technically, a 1-ft elevation difference) every time it "beeps." You need two Dipstick® readings (two "beeps") to get a Flatness measurement. This flatness measurement is called a "Q-reading," or just "Q." To measure the flatness of a floor, we'll need to collect a lot of these "Q's" and do some statistical processing with them.

"Q" is a "Flatness" measurement, and is the difference between two successive Dipstick readings, or the difference between two successive slopes.

Levelness Measurement:

The quality we call "Levelness" is somewhat more difficult to define mathematically. Every 4-year old knows that if he puts his marble down on a surface that is not level, the marble will roll away from him. But how do we measure "Levelness" objectively on a floor slab? If I use a rod and level to measure the four corners of a slab, and all four corners are at the same elevation, can I say that the slab is "Level?" Not if there is a drain in the center of the slab… the 4-year old kid will tell you that the floor is NOT level, because his marbles rolls toward the drain. To resolve this problem, we will measure the elevations of many points that are each spaced 10 ft apart. If two points that are 10 ft apart are at the same elevation, then we say that the line that joins them is "level," at least over this ten-ft length. We define the difference in elevation over a 10-ft distance as a "Z-Reading," or just "Z." To measure the levelness of a floor, we'll need to collect many "Z's" and do some statistical processing with them.

"Z" is a "Levelness" measurement and is a 10-ft elevation difference.

We need to collect both types of data - "Q's" and "Z's." You get a "Q" after you have measured 2 ft of data: With two Dipstick readings, you take the difference between the readings to get a "Q." That is, the difference between reading #1 and reading #2. To get another "Q," we only need to take one more step, because the second "Q" is the difference between Dipstick reading #2 and Dipstick reading #3. For each additional Dipstick reading you collect, you get one more Q. When you think about it, the number of Q's you get from any line equals the length of the line minus 1. Two steps gives you the first Q, three steps gives you the second Q, four steps gives you three Q's, and so on. From the start point to step 2, from step 1 to step 3, from step 2 to step 4, and so on. So the number of Q's you collect on a line is:

#Q's = (Line Length - 1)

Because a "Z-Reading" is a 10-ft elevation difference, you don't get your first Z until you have collected 10 steps worth of data. But the very next step gives you a second Z, and the twelfth step gives you a third Z. From the start point to step 10, from step 1 to step 11, from step 2 to step 12, from step 3 to step 13, and so on. You can see that you lose the first nine readings, then you start collecting Z's, one per step. So the number of Z's you collect on a line is:

#Z's = (Line Length - 9)

For example, a 20-ft line would get you (20-1 = 19) Q's and (20-9 = 11) Z's
A 50-ft line would get you (50-1 = 49) Q's and (50-9 = 41) Z's.

From this, you can see that the number of Q's that you collect will always be greater than the number of Z's that you collect. For statistical purposes, if you gather enough Z's, to have statistical significance, you will always have enough Q's. For this reason, the minimum amount of data to be collected focuses on the number of Z's you collect, and is called $\mathbf{N_{MIN}}$.

Since N_{MIN} is the absolute minimum number of Z's you need to collect, you will always need to have at least N_{MIN} Z's. (or more) With any process that depends on statistical sampling, collecting more data always results in a better answer. So it's good to collect more than the absolute minimum number of Z's. But collecting data takes time, and time is money, so there is a limit to how much data you would really want to collect. Although it is always true that more data gives a better answer, there is also the factor of diminishing returns. If, for example, John collects exactly N_{MIN} Z's on a Test Section, and Mary collects 1.5 times N_{MIN} Z's on the same floor, and Harry collects 10 times N_{MIN} Z's on the same floor, you should know that all three people will have very similar F-Numbers. The purpose of specifying N_{MIN} is to ensure that everybody who follows the rules of ASTM E-1155 gets good data. But Mary's F-Numbers will be a little more accurate than John's, since she collected more data. Harry's F-Numbers may be virtually indistinguishable from Mary's, because what Harry did was really overkill. The important thing to remember is to always always collect at least N_{MIN} Z's. And if you have the chance, collect a few more than N_{MIN}.

How Much Data Is Needed for each Section?

It's logical that the larger the floor to be measured, the more data you need to collect. In general, if the floor is large, more data needs to be collected. With any statistical sampling process, the more data you collect, the better the answer you get. Measuring floors is no exception to the rule, so in general, more data is better. But collecting more data takes more time, and time is money, so we need to know the **minimum** amount of data that we need to collect in order to have a good statistical sample. ***For most Test Sections***, the formula for determining the *minimum* amount of data to collect is simple:

If $A \geq 1600$ sf, $\mathbf{N_{MIN} = A/30}$
Where N_{MIN} is the Minimum number of "Z" samples to be collected, and A is the area of the surface in square feet.

In the ***special case*** where the Test Section is quite small, under 1600 square feet, we need to use a different formula for determining the *minimum* amount of data to collect:
If $A < 1600$ sf, $\mathbf{N_{MIN} = 2\sqrt{A}}$

This formula requires you to take somewhat more Z samples per square foot than [N_{MIN} = A/30]. That's because if you were to collect only A/30 samples, as the size of the floor gets small, the number of samples would be insufficient.

Organization of the Floor into "Surfaces" and "Sections"

The very first thing you need to do is establish the "Test **Surfaces**" and "Test **Sections**" for your job. Each job must contain one or more Test Surfaces, each with a different set of specified Overall F-Numbers. If your job has only one specified F_F/F_L value, you only need one "Surface". If two or more different F_F/F_L values have been specified for your job, you will need two or more Surfaces, one for each different specified overall F_F/F_L value. You may or may not have specified minimum local F_F/F_L values.
Each Surface must have at least one Test Section that is subordinate to it, and each Test Section must have at least one (or more) "Run" of data that is at least 11 steps long. .

ASTM E 1155 does not allow you to measure across construction joints, so the largest Test Section you can measure is a single slab or placement. If the pour is small, the pour itself can be the Test Section. However, if the pour is quite large, you should consider subdividing the pour into several smaller Test Sections to cover the entire placement. Where the structure is supported by columns, you may divide the pour along column lines or half-column lines to get a reasonably-sized Test Section. (Pick the column lines that will give you a reasonably-sized Test Section.)

- If the slab is not very large, you can treat the whole slab as a single Test Section.
- We recommend that whenever possible, Test Sections should typically be between 2000 – 8,000 square feet. The smallest slab that can be tested in strict accordance with ASTM E-1155 is 320 square feet. There is no formal upper limit, but the Face Company prefers to use Test Sections that are less than about 8K sf.

The drawback to using very large Test Sections is that bad parts of the floor can get "averaged in" with the good parts, and you wouldn't know it. If there is a lot of "good" floor, this can hide a relatively small part of the floor that is "bad".

The drawback to using very small Test Sections is simply that statistical processes (like ASTM E-1155) don't work well with small numbers. If the test Section is very small, you will be computing the F-Numbers based on a very small number of Q and Z samples. Bigger Test sections mean more data, and as usual, more data is better for any statistical process.

The number of **Surfaces** you need depends on how many different specifications you have for this job, while the number of **Sections** you need to have depends on the number of placements and the size of the placements.

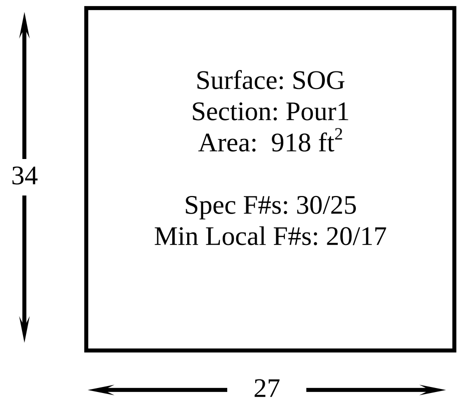
Remember, every Job must have at least one **Surface**, with spec FF and FL values.
Each Surface must have at least one **Section**, which cannot cross construction joints.
Each Section must have at least one **Run** or "line" of data. (normally, there will be two or more runs)
Each Run must consist of at least **11 Steps** before it can be used for ASTM E-1155 purposes.

<u>Example 1. - a small pumpstation</u>
This is a very small Job with one Surface and one Section (one small pour).

Job Name: Pumpstation_3 (*When there is only 1 Surface, the Surface name can be the Job name.)*
Surface Info:
- Surface Name: **SOG**
- Specified Overall $\mathbf{F_F}$ **30**
- Specified Overall $\mathbf{F_L}$ **25**
- Minimum Local $\mathbf{F_F}$ **20**
- Minimum Local $\mathbf{F_L}$ **17**
- Surface Area: **918 ft^2**

Section Info:
- Section Name: **POUR1**
- Section Size: **34 ft. X 27 ft.**

(no other Surfaces or Sections)



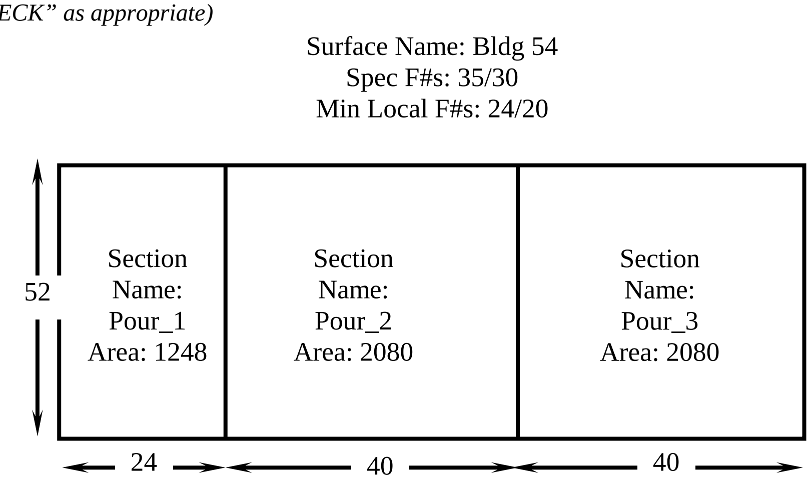
<u>Example 2.</u> **Small job with one Surface and three Sections** (three small pours with the same specified F-Numbers) **52 ft X 24 ft., 52 ft X 40 ft, and 52 ft X 40 ft.**

Job Name:**DOT Maint Bldg_54**

Surface Info:
- Surface Name: **Bldg 54** *(When there is only 1 Surface, the Surface name can be the Job name, or you can simply call the Surface "SOG" or "DECK" as appropriate)*
- Specified Overall $\mathbf{F_F}$ **35**
- Specified Overall $\mathbf{F_L}$ **30**
- Minimum Local $\mathbf{F_F}$ **24**
- Minimum Local $\mathbf{F_L}$ **20**
- Surface Area: **5408 ft^2**

Section Info:
- Sec 1 Name: **Pour_1**
- Section 1 Size: **52 ft. X 24 ft.**
- Sec 2 Name: **Pour_2**
- Section 2 Size: **52 ft. X 40ft.**
- Sec 3 Name: **Pour_3**
- Section 3 Size: **52 ft. X 40 ft.**

(no other Surfaces or Sections)



Example 3.

Large Job with two (or more) different Surfaces. This example is a hotel with different specs for the lobby and rooms. There are many pours.

Surface Info: Lobby

Surface Name:	**Lobby**
Specified Overall F_F	**45**
Specified Overall F_L	**40**
Minimum Local F_F	**30**
Minimum Local F_L	**27**
Surface Area:	**11,544 ft^2**

Section Info:

Sec 1 Name:	**Lobby Front**
Section 1 Size:	52 ft. X 87 ft.
Sec 2 Name:	**Lobby Rear**
Section 2 Size:	39 ft. X 87 ft.
Sec 3 Name:	**Atrium**
Section 3 Size:	39 ft. X 93 ft.

One Surface with three Sections

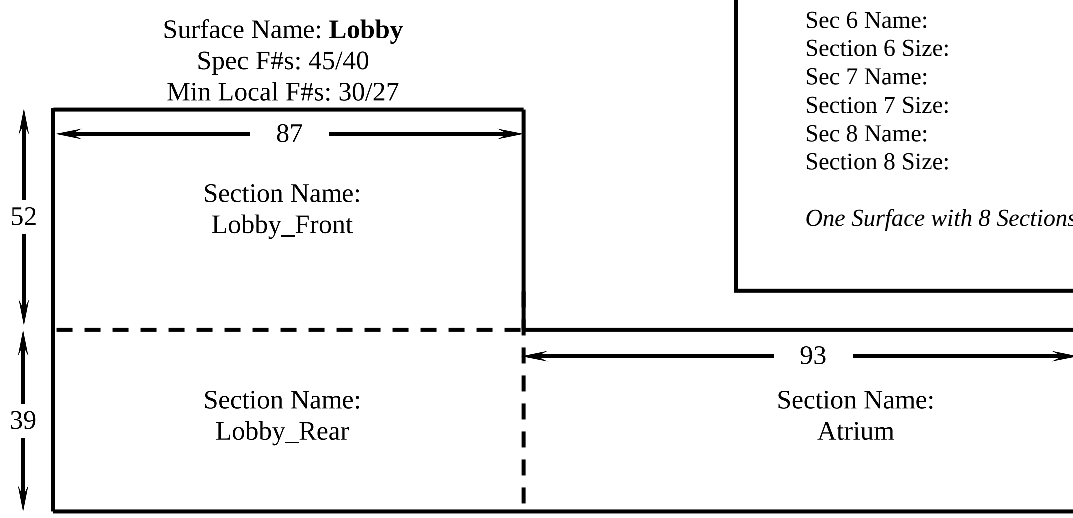
Surface Info: Rooms

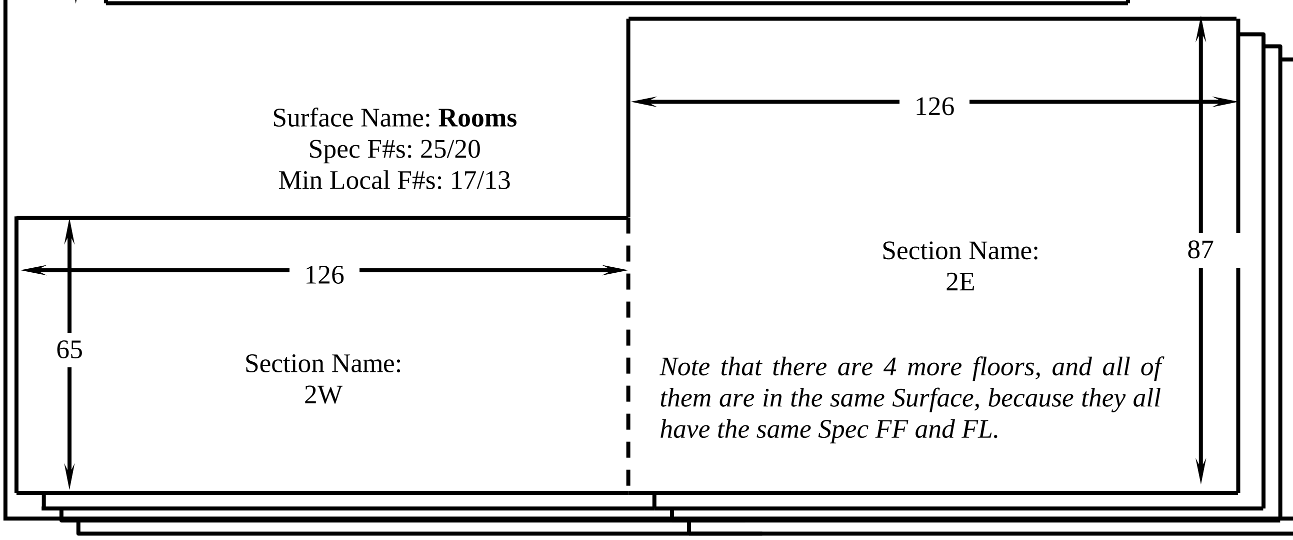
Surface Name:	**Rooms**
Specified Overall F_F	**25**
Specified Overall F_L	**20**
Minimum Local F_F	**17**
Minimum Local F_L	**13**
Surface Area:	**195,160 ft^2**

Section Info:

Sec 1 Name:	**2E**
Section 1 Size:	205 ft. X 142 ft.
Sec 2 Name:	**2W**
Section 2 Size:	205 ft. X 96ft.
Sec 3 Name:	**3E**
Section 3 Size:	205 ft. X 142 ft.
Sec 4 Name:	**3W**
Section 4 Size:	205 ft. X 96ft.
Sec 5 Name:	**4E**
Section 5 Size:	205 ft. X 142 ft.
Sec 6 Name:	**4W**
Section 6 Size:	205 ft. X 96ft.
Sec 7 Name:	**5E**
Section 7 Size:	205 ft. X 142 ft.
Sec 8 Name:	**5W**
Section 8 Size:	205 ft. X 96ft.

One Surface with 8 Sections





Example 4. **Large job with a single specification and very large pours.**

This example is a random traffic distribution center (warehouse). The roof over the slab on grade is supported by columns on 42-ft centers in one direction and 27-ft centers in the other direction. This is 113,400 ft^2 .

Surface Info:

Name:	**SOG**
Specified Overall **F_F**	**45**
Specified Overall **F_L**	**35**
Minimum Local **F_F**	**30**
Minimum Local **F_L**	**23**
Surface Area:	**113,400 ft^2**

Section Info:

All Section Size:	**42 X 54 ft**
Sec 1 Name:	**A-AB_12**
Sec 2 Name:	**A-AB_23**
Sec 3 Name:	**A-AB_34**
Sec 4 Name:	**A-AB_45**
Sec 5 Name:	**A-AB_56**
Sec 6 Name:	**AB-B_12**
Sec 7 Name:	**AB-B_23**
Sec 8 Name:	**AB-B_34**
Sec 9 Name:	**AB-B_45**
Sec 10 Name:	**AB-B_56**
Sec 11 Name:	**B-BC_12**
Sec 12 Name:	**B-BC_23**
Sec 13 Name:	**B-BC_34**
Sec 14 Name:	**B-BC_45**
Sec 15 Name:	**B-BC_56**
Sec 16 Name:	**BC-C_12**
Sec 17 Name:	**BC-C_23**

Etc.

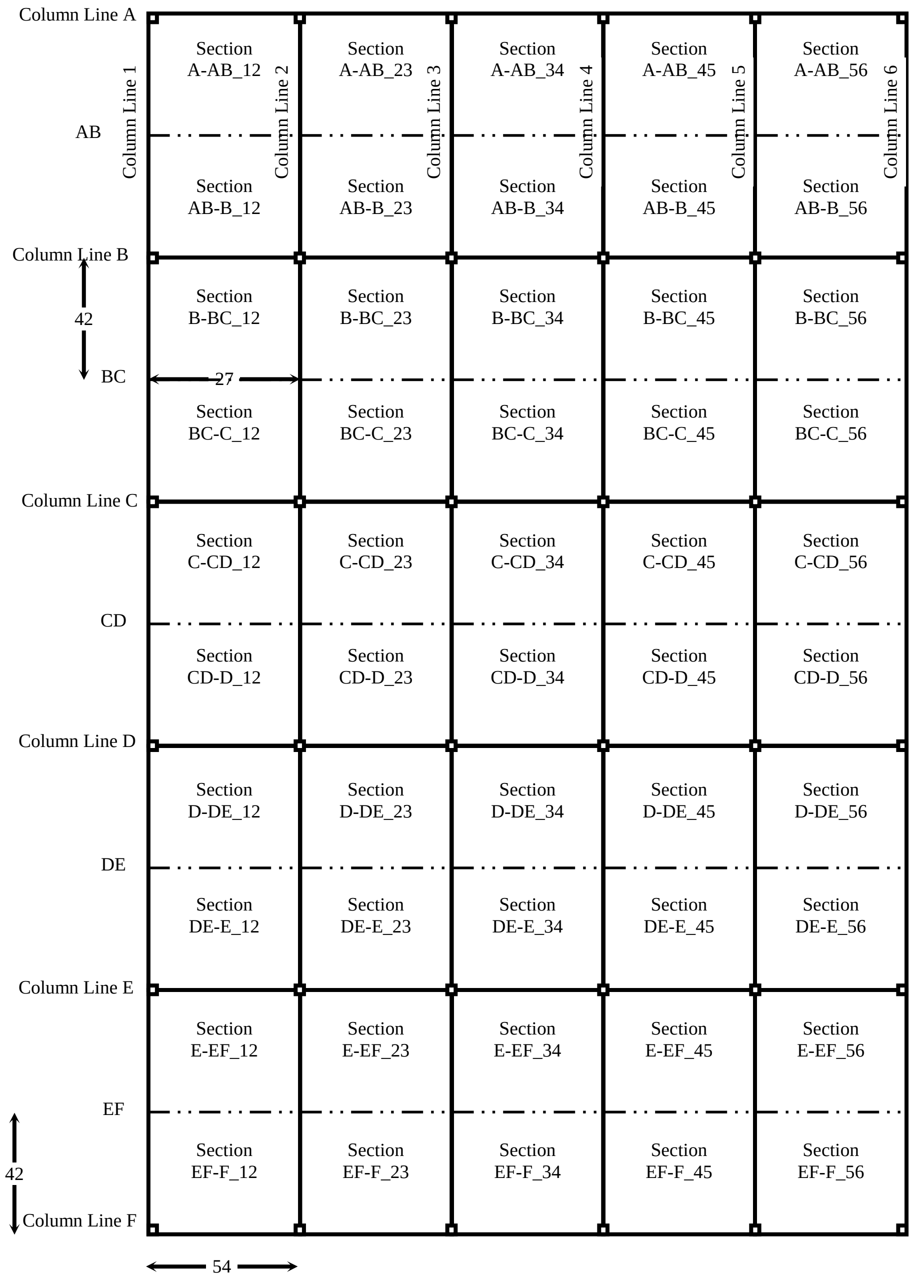
Each Section has 2268 sf of concrete floor.

One Surface with 50 Sections
(only 1 spec, so only 1 Surface is needed)

In this example, Sections are named for the column lines & half-column lines.

Note: It would also be possible (and perfectly legal) to make the Test sections based on column lines in both directions. In this case, you'd have half as many Test sections, (25) each one twice as large as those shown here. (4536 sf each)

Overall floor dimensions: 420 ft X 270 ft: 113,400 ft^2
Job Name: **XYZ Distribution Center**



Where to Collect the Data - The "2-Ft Boundary"

Because a floor slab is finished by hand near any stub-ups, penetrations, block-outs, and around the perimeter of the slab, ASTM E-1155 requires that you stop measuring before you get within 2 ft of any of construction joints, block-outs, stub-ups, and other discontinuities. The idea is to measure only the large portion of the slab that is NOT finished "by hand," because all parts of the slab that are machine-finished should be statistically similar. The small fraction of the slab that is near the edge, near block-outs, pipes that penetrate the surface, etc, may be "different" because it is hand-finished. Note that sawcuts are ***not*** considered to be discontinuities under this rule, because the entire floor surface is finished before the sawcuts or "crack control joints" are made. So you ***may*** measure across sawcuts, but not across construction joints or within 2 ft of penetrations or block-outs.

Exception to the 2-Ft Boundary rule:

In the unusual case where a floor slab is so small or so narrow that the 2-ft exclusion rule prevents you from measuring at least 75% of the total area, the 2-ft boundary rule does not apply. In this case, you may measure from one edge of the slab to the other, and you may measure within 2 ft of penetrations, etc.

This requires you to calculate the area that is excluded by the 2-ft boundary rule on every Test Section, and determine what percentage is to be excluded. ***If the area to be excluded exceeds 25% of the total area, then you ignore the 2-ft boundary and measure all the way across the slab.***

Where to Collect the Data - What direction will the lines run?

ASTM E-1155 requires that all lines of data be straight lines that run parallel to and perpendicular to the longest test section boundary. If the slab is rectangular, with the long axis running North to South, then the measurement lines must be both North-South and East-West. If the slab happens to be triangular in shape, the lines must run both parallel to and perpendicular to the longest side of the triangle.

Alternate Method:

You may also choose to run the lines at 45° angles to the longest test section boundary.

You may **NOT** collect lines of data at any other orientation. All lines must be either:

a) Both parallel to and perpendicular to the longest test section boundary, or
b) At 45° to the longest test section boundary.

I'll say it again: You may NOT use lines that run in any other direction. For example, you may NOT use corner-to-corner diagonals (except on a square slab, where the corner-to-corner diagonals are automatically 45º). And you can't mix 45º diagonals and "Parallel & Perpendicular" lines.

Special Case:

If the test section is less than 25 ft wide, then you **must** use the 45° diagonal "Zig-Zag" layout method. ***(You may NOT use the "Parallel & Perpendicular" method if the test section is less than 25 ft wide.)***

How to Collect the Data - How long will the lines be?

The lines (Runs) must be straight and at least 11 ft long. You will find that longer lines are more efficient. Since you lose 9 steps on each Run before you begin to get your first "Z-Reading," longer lines are much more efficient at gathering more Z-Readings faster.

Because of the 2-ft boundary rule, the lines must be at least 4 ft shorter than the length and width of the slab. There is one more restriction on line length:

Additional Restriction:

If you use the "Parallel & Perpendicular" method (Using lines both parallel to and perpendicular to the longest test section boundary), then ***the number of lines in each of the two directions must be equal, and the total length of all the lines in one direction must equal the total length of all lines in the other direction.*** ASTM E-1155 words it this way: You must use "equal numbers of lines of equal aggregate length." This means that the total length of all the lines that run North-South must equal the total length of all the lines that run East-West.

The reason for this requirement is so that the data you collect will represent the North-South direction just as much as the East-West direction. For example, if the flaws in a particular floor tended to be aligned in an East-West direction, then the lines that run across them North-South would show the humps and bumps more than the lines running along the flaws. If you collected more data in the North-South direction, you would skew the data, making the floor look worse than it really is. Conversely, if you collected more data in the East-West direction on this floor, your lines would run along the same direction as the flaws, and you would make the floor look *better* than it really is. Our goal is to tell the truth, as best we can, so we need to take equal numbers of steps in both directions.

The simple and easy way to determine line length is to make all lines equal to the width of the slab (the shorter of the two dimensions) minus 4 ft. (This allows for the 2-ft boundary.)

Exception: *If you collect data on lines that run at 45° diagonals, you don't need to make the total number of "Zigs" equal to the total number of "Zags", and you don't even need to have the total length of the "Zigs" equal the total length of the "Zags".* The reason you can do this with 45° lines is because the projection of a 45° line is the same on a horizontal or vertical surface. This is not true of any other angle.
Remember that the number of "Z's" that you get from a line is equal to the length of the line minus 9. So two 12-ft lines will generate 2 x (12-9) = 2 x 3 = 6 Z's.
And a single 24-ft line (the same total number of steps as two 12-ft lines) will generate 24-9 = 15 Z's. You can see that ***longer lines (Runs) are much more efficient than short lines.*** So you want your lines to be as long as possible. You would like to make the lines run from one side of the slab to the other. Unfortunately, that would create two problems.

Problem #1:

You are not allowed to measure within 2 ft of a slab boundary, stub-up, penetration, or block-out. *Because of this, you need to make the lines equal to the width minus 4 ft.* (Staying 2 ft away from each edge). *Unless, of course, the excluded area is greater than 25% of the total area.*

Problem #2:

Also, if the length is greater than the width, then if you collect lines that run the full length and full width of the slab, the Runs that go the length of the slab will of course be longer than the Runs that go the width of the slab, and you will have collected more data in one direction than the other. If you collect more data in one direction than the other, then the F-Numbers you get will be skewed (biased) in the direction of the longer runs. *Because of this, you need to collect the same number of lines in both directions, and the total length of the lines in each direction must be equal.* This does *not* mean that all the lines need to be the same length. Just the total sum of all the lines in the north-south direction must equal the sum of all the line lengths in the east-west direction.

The easiest way to do this is to make your lines equal to the width (the shorter of the two dimensions) minus 4 ft. If you make all the lines the same length, and if you put half the lines on the slab in one direction, and half in the other direction, you automatically satisfy the requirement that ***the number of lines in each of the two directions must be equal, and the total length of all the lines in one direction must equal the total length of all lines in the other direction.*** The transverse lines (across the width of the slab) will fit neatly up against the 2-ft boundary on both sides. Just spread them out evenly. The longitudinal lines will not reach from side to side, so you will need to stagger them. All you need to do is spread them evenly along the length of the slab, and distribute them evenly across the width of the slab. See the example below.

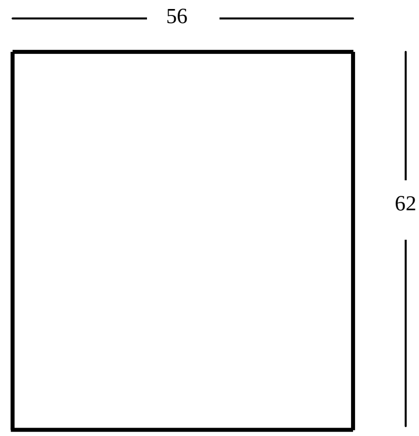
45º Zig-Zag lines: 45º diagonal lines are always longer than transverse lines. To determine the length of a 45º diagonal Run, use the transverse length times √2. Normally, this is (W-4)*√2.

How to Collect the Data - How many lines do you need?

At this point, you have already calculated the area of the slab, and you know how many "Z's" that you need to collect. You have also decided whether or not to use the 2-ft boundary, and you have determined how long the lines will be. What you need to know now is how many lines of data to collect. (We call the lines of data "Runs")

You have already calculated N_{MIN}, the minimum number of Z-Readings that you need to collect. You also know that each line you collect will generate (Line Length - 9) Z's. Simply divide N_{MIN} by the number of Z's per line to figure out how many lines you will need. You will almost never need an integer (whole number) of runs. But since you need to collect a *minimum* of N_{MIN} Z-Readings, you should round the number of lines up to the nearest whole number. If you are using the "Parallel and Perpendicular" layout method, you will need to round the number of lines up to an even number of Runs. This is because you need the same number of lines in each direction. If you are using the 45º diagonal method, you don't need an even number of lines. Once you decide how many lines you need, just lay them out evenly across the slab.

An Example Layout

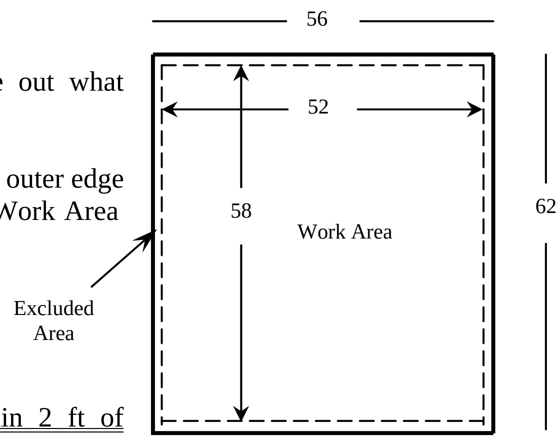


You know how many lines to run, and how long they need to be. You also know that the lines need to be distributed evenly across the slab.

Step 1: Find the Area and determine N_{MIN}:

A = 56 x 62 = 3472 ft^2
Since the area is greater than 1600 ft^2, N_{MIN} =A/30.
N_{MIN} = 3472/30 = 115.73

Please note that $\mathbf{N_{MIN}}$ is 115.73, and you can't collect a fraction of a Z-Reading. You can only collect a whole number, either 115 or 116. Since115.73 is the MINIMUM, you need to collect 116, which is just over the minimum. So **N_{MIN} = 116**



Step 2 - Determine if it's OK to use the 2-Ft boundary:

First find the work area, then the excluded area, and figure out what percentage will be excluded.
The Work Area is the area that is inside the 2-ft boundary.
The Excluded Area is the area between the 2-ft boundary and the outer edge of the slab. To determine the Excluded Area, just subtract the Work Area from the Total Area.

In this example, the Work Area = 52 x 58 = 3016 ft^2
The Excluded Area = A_{TOTAL} - A_{WORK}
Excluded Area = 3472 - 3016 = 456 ft^2
% excluded = $A_{EXCLUDED}/A_{TOTAL}$ = 456/3472 = 0.1313 = 13%
Since less than 25% is excluded, you do not measure within 2 ft of construction joints, penetrations, stub-ups, blockouts, or any other discontinuity in the floor surface. .
Note: Any time the excluded area exceeds 25% of the total area, you would measure everywhere, without regard to any 2-ft boundary.

Step 3 - Which Way Will the Lines Run?

In this case, since the slab is over 25 ft wide, you can use either of two methods: Parallel & Perpendicular, or Zig-Zag (45º diagonals). It's your choice. In the illustrations that follow, we'll show you what each one looks like.

Step 4 - How Long Will the Lines Be?

The longest line that you can run parallel to the slab boundaries in both directions is 52 ft.
(If the line were any longer, you'd be stepping into the Excluded Area.)

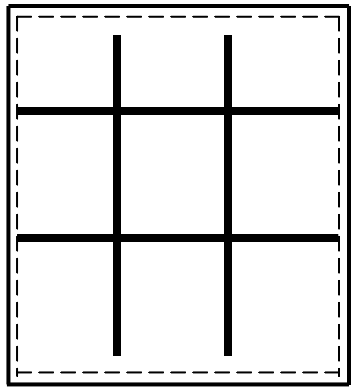
Step 5 - How many lines do you need?

Since each line will generate (52-9) = 43 Z-Readings, and you need a total of at least 116 Z-Readings, you will need to collect 116/43 = 2.7 Runs. You can't collect 2.7 runs - you can get either 2 runs or 3, but not 2.7. So we'll round the number up to 3 runs instead of 2.7 runs.

But we need to have the same number of runs in both directions, so we'll need an even number of runs, and we'll need to round the number of Runs up to 4.
The answer (for parallel and perpendicular layouts) is four Runs.
Two runs North and South, and two runs East and West.

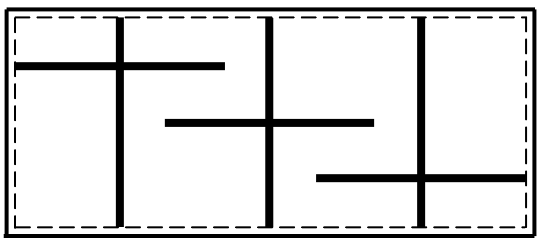
Here's what it looks like:
This layout resembles a "Tic-Tac-Toe" pattern.
The lines are the same lengths in both directions.

The Runs just touch the boundary in the E-W direction, but don't touch them in the N-S direction.



The following examples show different types of layout patterns, so you can see how to handle them when you have different numbers of lines to place on the slab.

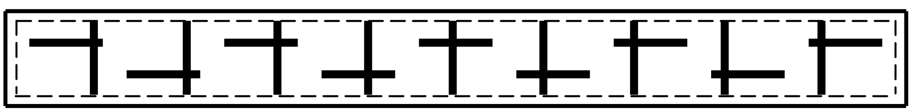
If your slab happened to be longer and thinner, you might need six Runs instead of four, and your layout pattern might look like this:



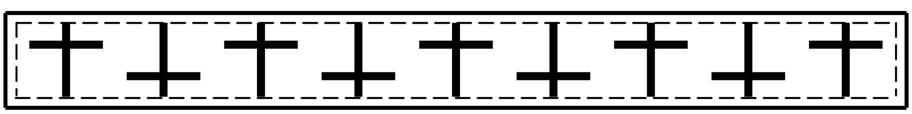
Note that the transverse lines (running N-S in this example) are spread evenly from left to right, and that the longitudinal lines are spread evenly from top to bottom as well as from left to right.

The lines are the same lengths in both directions.

If the slab was very long and narrow, you might need eighteen short Runs, (nine in each direction) and your layout might look like this:



Or this:

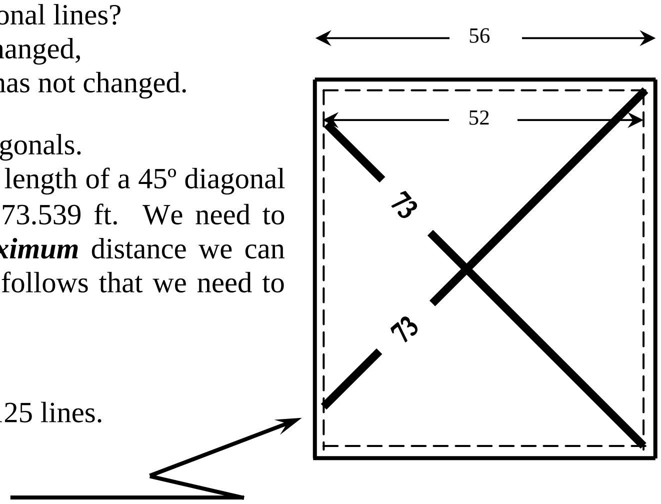


Either one is OK.

Which is better - Parallel & Perpendicular or Zig-Zag?

Generally speaking, the "Parallel & Perpendicular" layout method requires a few more steps than the "45º Zig-Zag" method, but it provides more useful data if you are trying to determine where the flaws are in the floor. If you use the "Parallel & Perpendicular" method, after all the data has been collected, you can select all the N-S runs and Report a "Combined Section." This will generate an "Ad Hoc" Combined Section that shows the combined F-Numbers of all the runs in the N-S direction. Then if you select all the E-W runs and Report Combined Section, you will get a second "Ad Hoc" Combined Section that shows the F-Numbers in the E-W direction. If one set of F-Numbers is significantly better than the other, then the flaws are not random, and The F-Numbers show it. You can also graph all the N-S runs together, then graph all the E-W runs together. You may see the problem on the graph. You can't do this as well when you use the "45º Zig-Zag" method.

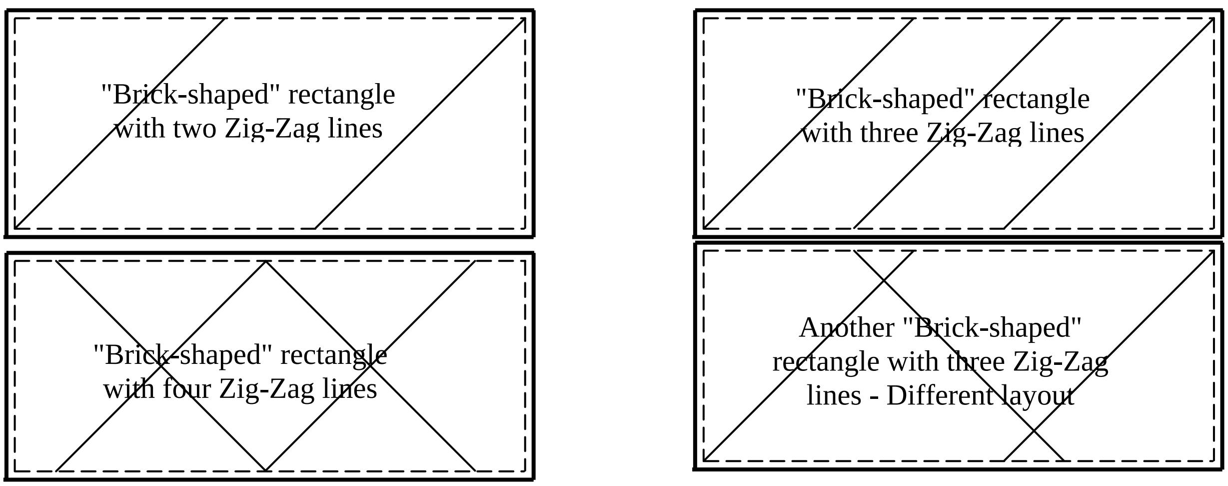
What if you chose a "Zig-Zag" pattern, using 45º diagonal lines?
Steps 1 and 2 would be the same: The Area has not changed,
N_{MIN} has not changed, and the percent Area Excluded has not changed.



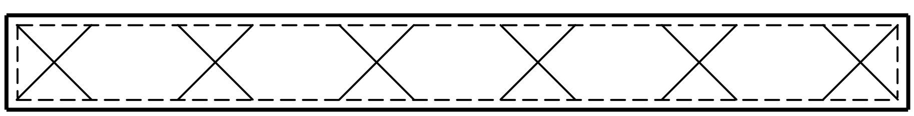
But the lines would be longer because they are 45º diagonals.
By geometry, if the width of the Work Area is 52, the length of a 45º diagonal line will be $52\sqrt{2}$, or 73.539 ft. We can't measure 73.539 ft. We need to measure either 73 ft or 74 ft. Since this is the ***maximum*** distance we can measure without stepping into the Excluded Area, it follows that we need to use lines that are only 73 ft long.

These 73-ft lines will each generate (73-9) = 64 Z's.
N_{MIN} is still 116, so we will need to have 116/64 = 1.8125 lines.
We are not going to try to measure a fraction of a line,
so we will use **two** Runs, each 73 ft. long as shown.
Note that we only need 2 x 73 = 146 steps when we use this method, compared to 4 x 52 = 208 steps when we use the "Parallel and Perpendicular" layout method.

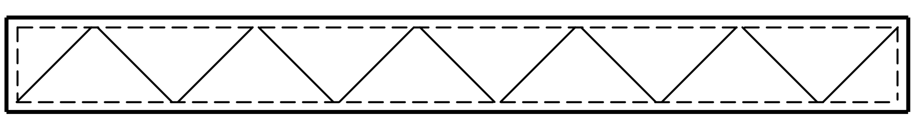
Other Layout Examples - here's how you might place the lines when you use the 45º layout pattern. ***Remember that you do not need to have the same number of "Zigs" and "Zags" when you use the 45º layout method.***



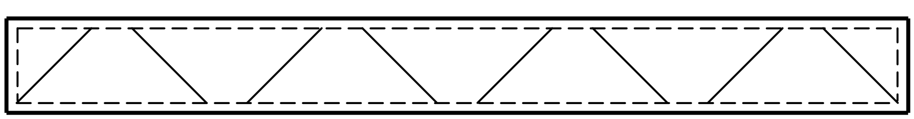
Long narrow rectangle with many Zig-Zag lines



Long narrow rectangle with fewer Zig-Zag lines



Long narrow rectangle with even fewer Zig-Zag lines



Summary of ASTM E1155 Rules

Minimum Section size: 320 sf (no maximum)

Minimum Section width: 8 ft

Number of Z-samples to be collected:

- If A ≥ 1600 sf, $\mathbf{N_{MIN} = A/30}$
- If A < 1600 sf, $\mathbf{N_{MIN} = 2\sqrt{A}}$
- These are the absolute MINIMUM number of Z's that need to be collected. More data is always better but takes time.

The 2-Ft Rule:

- Do not collect any data within 2 ft of any construction joint, penetration, block-out, stub-up, or other discontinuity in the floor. This means, of course, that a Section can't be larger than a single pour.
- *But If the area to be excluded exceeds 25% of the total area, then you ignore the 2-ft boundary and measure all the way across the slab.*
- *You can cross Sawcuts, (Crack Control Joints) but you can't cross construction joints.*

Line Length:
All lines ("Runs") must be straight and ≥ 11 ft long. Longer lines are more efficient, so use longer lines if you can.

Line spacing:
All lines must be at least 4 ft from any other parallel line.

Line Orientation:
All lines must be EITHER

- Parallel & Perpendicular to the longest Test Section boundary, or
- At 45 degrees to the longest Test Section boundary. (No corner-to-corner diagonals)

Note: **If** you use the Parallel & Perpendicular method,

- You must have the same number of lines in both directions, E.g., 3 N-S lines and 3 E-W lines.
- Lines in both directions must also have the same total length, E.g., 127 total steps N-S and 127 total steps E-W. But the individual lines can have different lengths so long as the totals in both directions are the same.

But if you use the 45 degree Zig-Zag method, neither of these restrictions apply.

Special Layout Restriction:
If the Test Section is less than 25 ft wide, you MUST use the 45 degree Zig-Zag method.

Line Locations
Place the lines uniformly across the Test Section. Try to spread them as evenly as possible.

Number of Z's collected per line: (Line Length -9)

You must use all valid data that you collect:
If you collect data, you must use it. You can't "pick and choose" which data to use.

Map: Make a sketch map of the Test Section and show where the lines of data are.

Chapter 2: How to Handle Irregular Test Sections

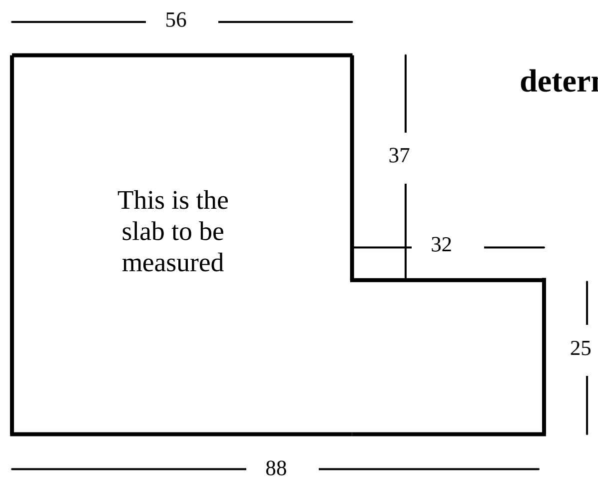
There are two general ways to handle test sections that are not rectangles or squares:

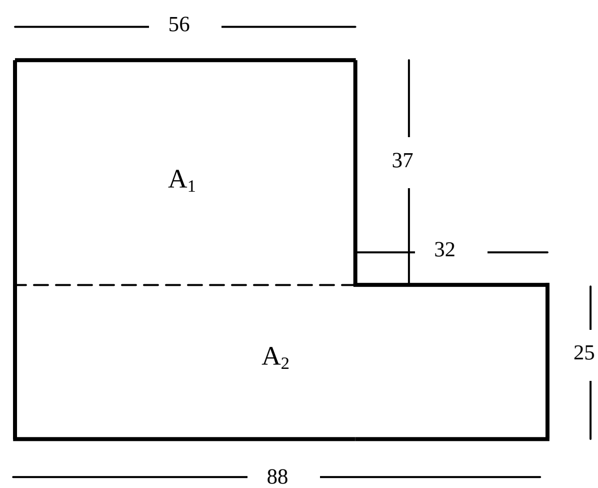
1. Determine the area of the irregular slab, then determine whether or not you should use the 2-ft boundary, then find Nmin, and decide how long the lines can be. ***This is just like the way we have been doing it, except you need to wrestle with an odd-shaped test section.*** Remember that you must have equal numbers of lines of equal total length in both directions. The lines do not all need to be the same length, but the number of N-S lines must equal the number of E-W lines, and the total length of all the N-S lines added together must equal the total length of all the E-W lines. Really the only thing that is different is that you need to be careful selecting line lengths. We'll show you how to do it below.
2. Alternate method: If the slab is "L" shaped, or is otherwise composed of two or more rectangles, you can break the slab into two or more smaller rectangles and work them independently as small slabs. ***While this method is simple to explain and do, it usually requires more lines and more data collection than the first method above.*** So you are usually better off working it out and placing the lines carefully by hand instead of treating it as two smaller sections.

We do not recommend treating this L-shaped slab as two smaller sections – especially if the smaller one is less than 1600 sf.

Example:

Step 1 - Calculate the Area of the slab and determine N_{MIN}:





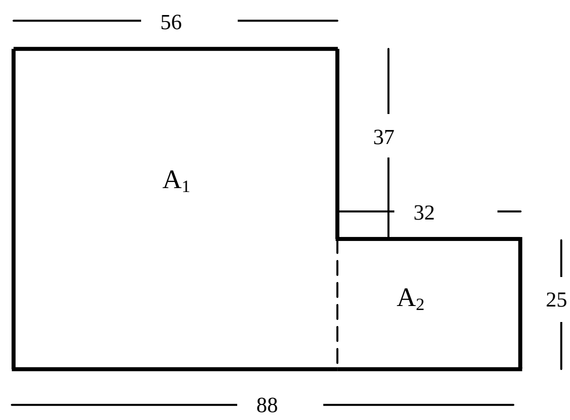
Find the area by adding the areas of the two rectangles together:

A_1 = 56 x 37 = 2072

A_2 = 25 x 88 = <u>2200</u>

Total Area = 4272

You can also calculate the area of the whole thing by using two different rectangles:



A_1 = 56 x (37 + 25) = 56 x 62 = 3472
A_2 = 25 x 32 = 800
Total Area = 4272

The area is the same, no matter how you do it.

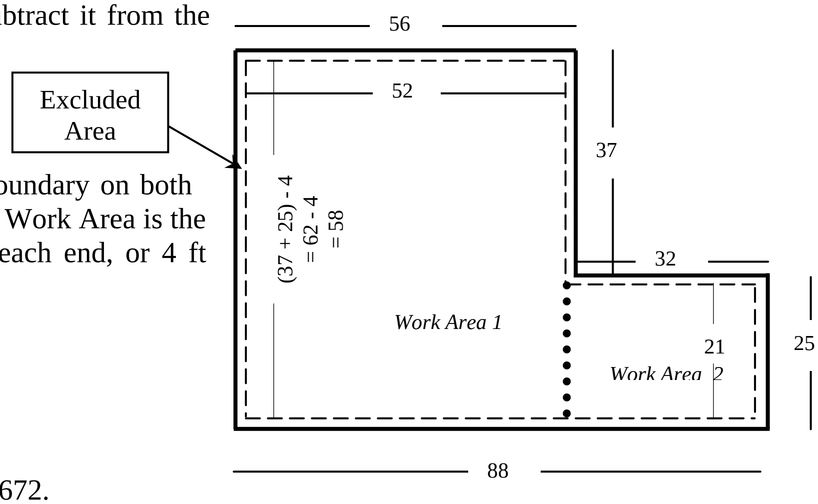
Since the total area is greater than 1600 ft^2,
$\mathbf{N_{MIN} = A/30}$ = 4272/30 = 142.4

Please note that $\mathbf{N_{MIN}}$ is 142.4, and you can't collect a fraction of a Z-Reading. You can only collect a whole number, either 142 or 143. Since142.4 is the MINIMUM, you need to collect 143, which is just over the minimum. **N_{MIN} = 143.**

Step 2 - Decide whether you can use the 2-ft boundary.

(You will always use the 2-ft boundary unless the Excluded area exceeds 25% of the total area.)

First calculate the Work Area, then subtract it from the Total Area to find the excluded area.



The Work Area is composed of two rectangles, slightly smaller than before. Since we are leaving a 2-ft boundary on both sides of the rectangles, the width of the Work Area is the same length as before, minus 2 ft at each end, or 4 ft shorter in each direction.

Work Area $_1$ = 52 x ((37 + 25) -4)
= 52 x (62 -4)
=52 x 58 = 3016

Work Area $_2$ = 32 x (25-4) = 32 x 21 = 672.
Total Work Area = 3016 + 672 = 3688

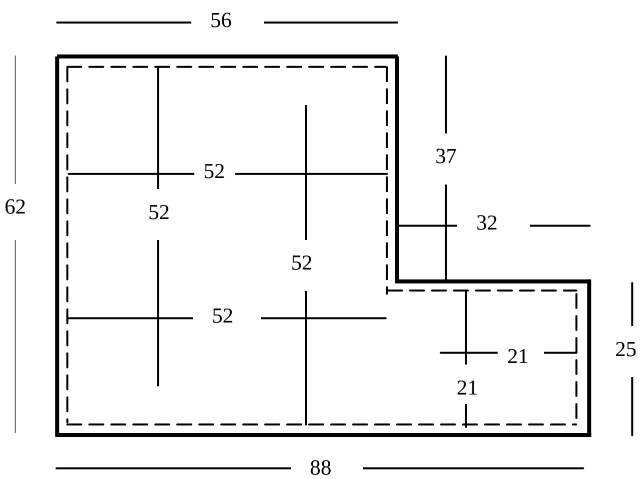
Area excluded = A_{TOTAL} - A_{WORK} = 4272 - 3688 = 584
% excluded = $A_{EXCLUDED}/A_{TOTAL}$ = 584/4272 = 0.1367 = 13.7%
Since less than 25% is excluded, it's OK to use the 2-ft boundary exclusion.

Step 3 - Determine How Long The Lines Can Be, and Where to Put Them:

This is the only part where you need to use some judgement.

- A line parallel to the longest slab boundary could be as much as 84 ft long, but you couldn't use those long lines in the other direction.
- You could easily use lines that are 21 ft long - and you could use them anywhere. These lines will give 21-9 = 12 Z's each. You would need 143/12 = 11.92 → <u>12 of these runs.</u> This would be way too many short lines to be efficient.
- You could use 52 ft long lines anywhere except N-S in the lower right corner. These lines will give 52-9 = 43 Z's each. You would need 143/43 = 3.32 → <u>4 of these runs.</u>

Sample layout #1, using Parallel and Perpendicular lines:



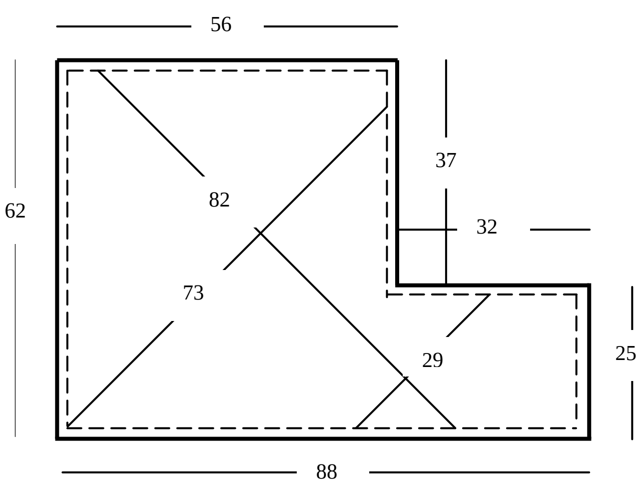
Using 4 runs of 52 ft each, plus 2 runs of 21 ft each, we get 4 x (52-9) + 2 x (21-9) Z's.
That's 4 x 43 + 2 x 12 = 172 + 24
Or a total of 196 Z's.
Remember, we only needed $\mathbf{N_{MIN}}$ = 143 Z's,
so we have more than enough.

And this is our layout pattern.

We have equal numbers of lines in both directions, and equal total length of lines in both directions.
(2 runs of 52 ft and 1 run of 21 ft each way)
52 + 52 + 21 = 250 steps each way

The total number of Dipstick® steps is
125 + 125 = 250 steps

Note that no line extends into the boundary area.



Using 1 run of 82 ft, yielding 73 Z's, plus one run of 29 ft with 20 Z's, and one run of 73 ft with 64 Z's, we get (73 + 20 + 64) = 157 Z's, which is more than enough.

We only needed $\mathbf{N_{MIN}}$ = 143 Z's, and we got 157.

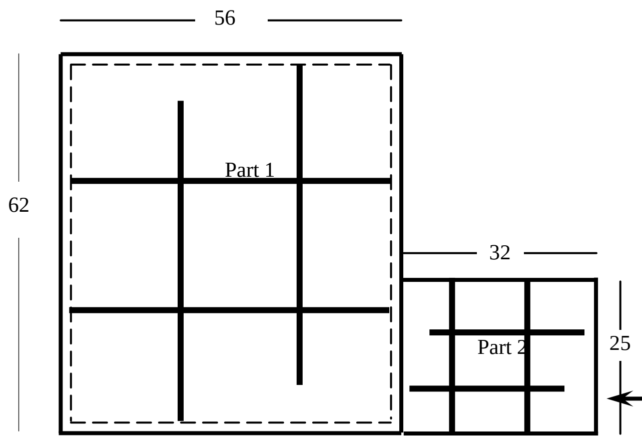
This is the Zig-Zag layout pattern.

Because the projection of any 45º line is equal along the X and Y axes, the Zig-Zag layout method does not require equal numbers of lines or equal total line length in both directions.

The total length of all lines is (82 + 29 + 73) = 184 steps.

Sample layout #2, using 45º diagonal lines:

If you decide to break this Test Section into two different Sections, here's what it would look like:
You would then deal with each of the two rectangles separately. (Each piece would become a new and independent Test Section.)



This small test Section would be very small (800 sf) This is so small that although it meets the minimum size requirements of ASTM E-1155, the Face Company does not recommend doing this. The excluded area for this small Test section is over 25%, so the lines must run the full 25-ft width.

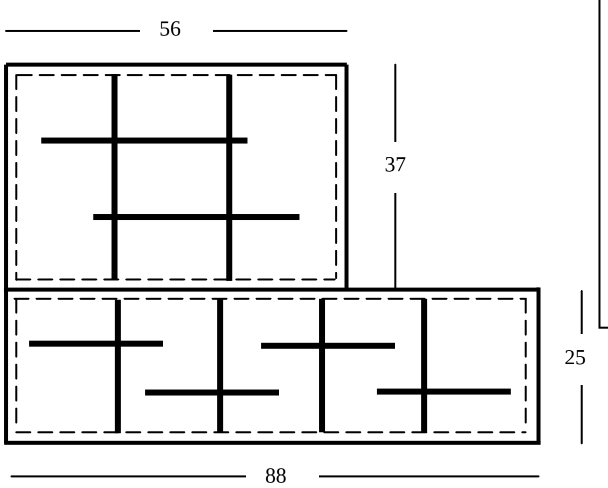
Total # of lines for these two Sections = 8;
Total # of Dipstick steps = 4 x 58 + 4 x 25 = 332

Or

Both of these smaller Test Sections are larger than 2,000 sf.

Total # of lines for these two Sections = 12;
Total # of Dipstick steps = 4 x 33 + 8 x 21 = 300

Although there are more lines in this method, the total number of Dipstick steps is slightly fewer than the example directly above.
Note that both of the methods shown on this page require more data than either method on the previous page.



Chapter 3: Summary of ASTM E-1155 Requirements

1. Determine N_{MIN}

Determine the total Area of the Test Section. $A_{TOT} = L \times W$

If the area is greater than or equal to 1600 sf, then **$N_{MIN} = A/30$.**
If the area is smaller than 1600 sf, then **$N_{MIN} = 2\sqrt{A}$**

2. Verify that you can use the 2-ft boundary.

You always use it unless the excluded area is greater than 25% of the total area.
Calculate the work area. $A_{WORK} = (L-4) \times (W-4)$
Calculate the Excluded area $A_{EXCLUDED} = A_{TOT} - A_{WORK}$
Calculate the % Excluded $\%_{EXCLUDED} = A_{EXCLUDED}/A_{TOT}$

If the $\%_{EXCLUDED}$ is greater than 25%, then you don't use the 2-ft boundary.

Otherwise (almost always) you will use the 2-ft boundary.

3. Check to see if you can use either Parallel & Perpendicular or 45º Zig-Zag Layout

If the width of the Test Section is 25 ft or greater, you can use either method.
If the width of the Test Section is less than 25 ft, you must use the 45º Zig-Zag method.

4. Determine the Line Length that you will use in your layout.

If you are using the Parallel & Perpendicular layout method:

In most cases, the length of the line will be the width of the Test Section -4 ft.
(Allowing for the 2-ft boundary)

If you cannot use the 2-ft boundary, then the line length will be the width of the Test Section.

If you are using the 45º Zig-Zag layout method:

Line Length = $(W - 4) * \sqrt{2}$

5. Determine how many Z's you will get from every line, then how many lines you need.

Z's per line = Line Length – 9 (round down)
\# Lines needed = N_{MIN}/Z's per line (round up)

6. Finally, place the lines uniformly across the Test Section.

Do this in a manner consistent with the examples in this booklet.

7. Measure the lines you have laid out.

You're done.
The Dipstick® software automatically calculates Combined Sections and Project Summaries. All you need to do is use **REPORT/PROJECT SUMMARY AND REPORT/COMBINED SECTION.**

Some people like to have a "Flow Chart" to remind them of the steps in the procedure. Others feel that these diagrams are confusing. We are providing the diagram below for your information in case you want to use it.