Single Part Tolerance Analysis[1]

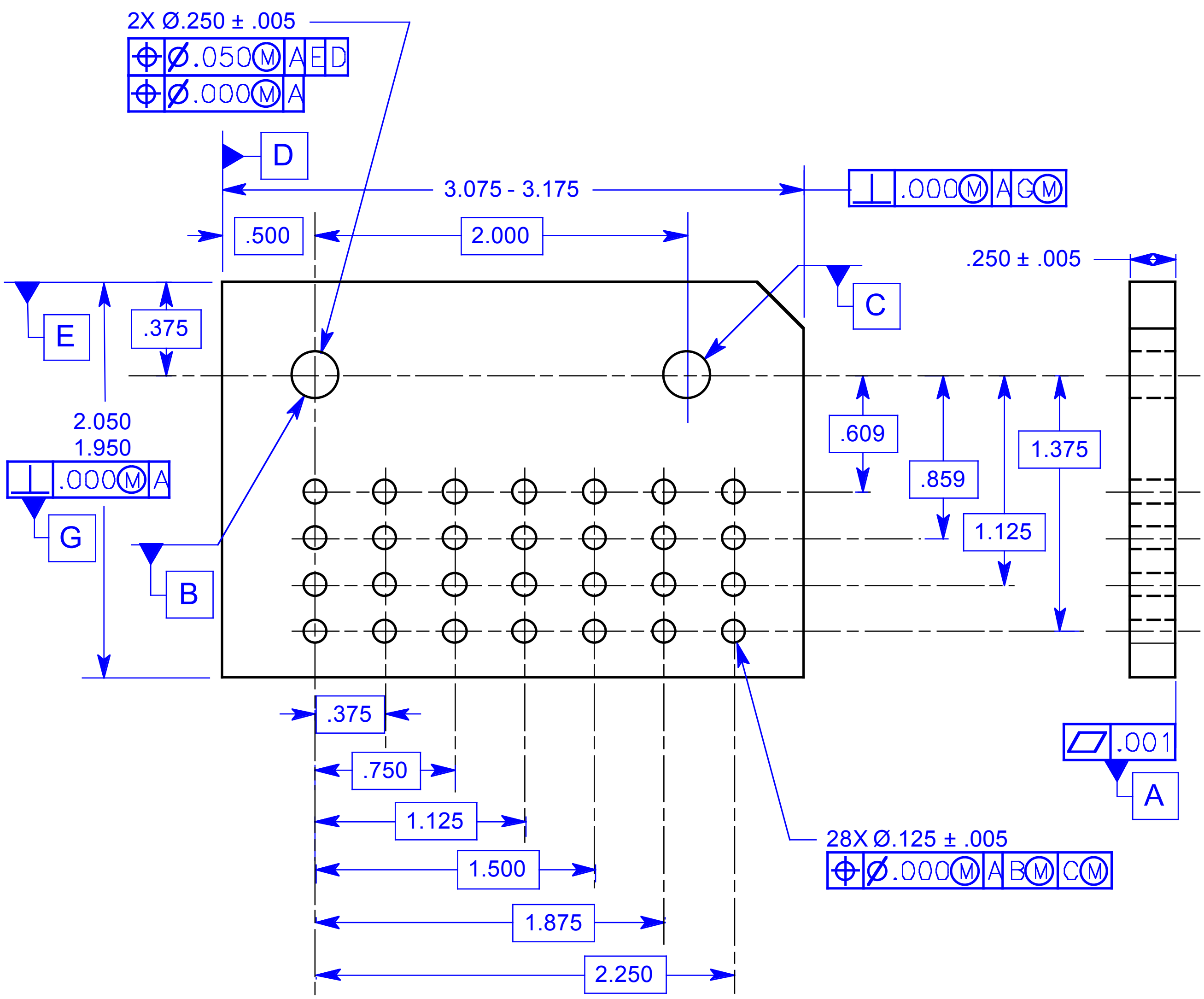

Figure 8-1 A pattern of features located to a second pattern of features

The engineer who designed the part above may want to determine how close the bottom row of the Ø.125 holes is to the bottom edge of the plate. This procedure is demonstrated in the 3 steps shown below.

Step 1: Determine what characteristic is to be analyzed. In this case, the gap in question is the shortest distance between the bottom hole and the bottom edge of the part.

[1]Cogorno, Gene R., ***Geometric Dimensioning and Tolerancing for Mechanical Design, Second Edition***, McGraw-Hill, New York, 2011, p. 120.

Step 2: Draw the loop analysis diagram. The loop analysis diagram is the circuit that connects all of the features that contribute to the gap under investigation.

Step 3: Determine the boundaries of each feature and convert them to equal bilateral plus or minus tolerances.

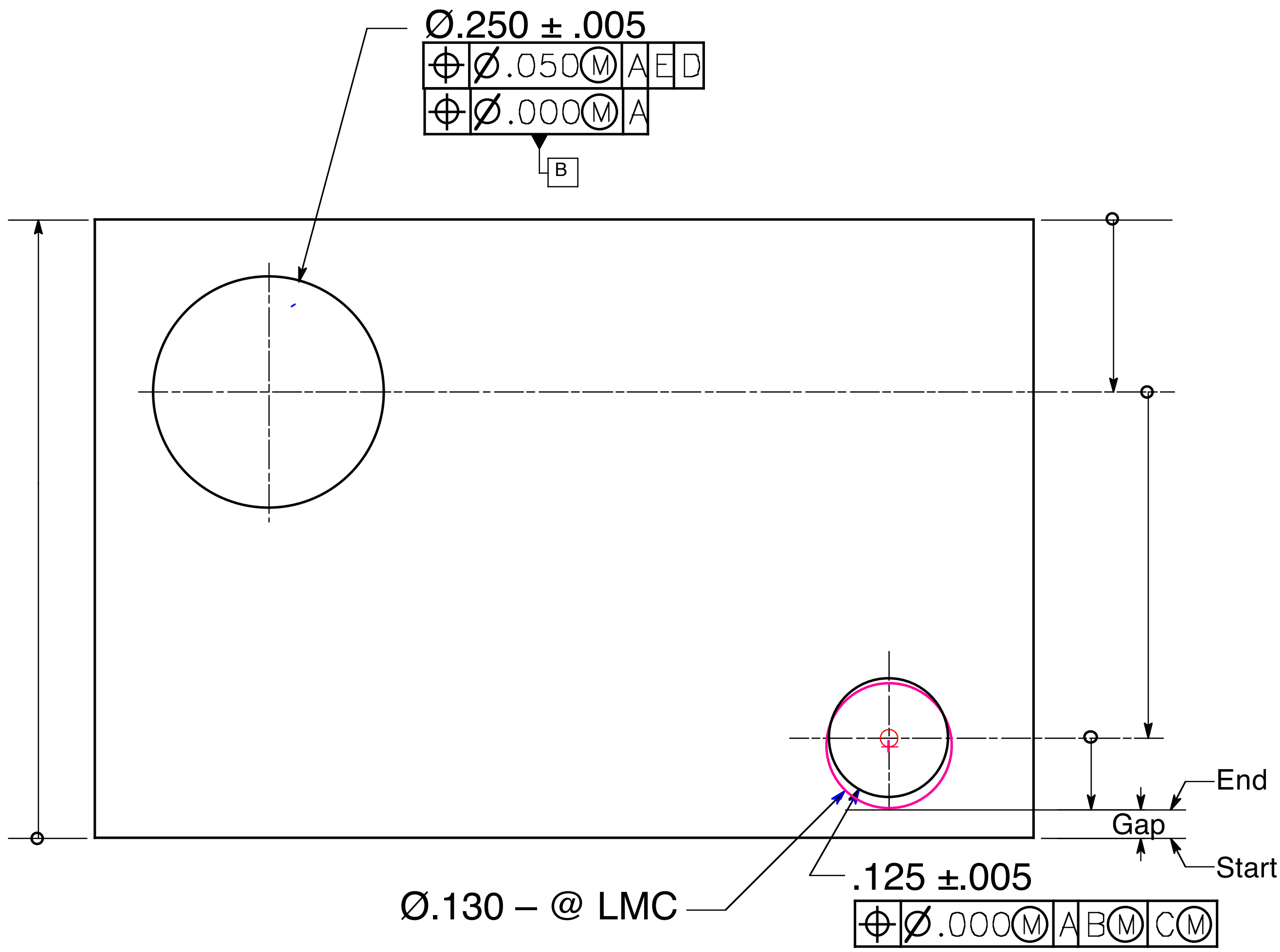

Figure 8-1A The loop analysis diagram is used to investigate the gap between the bottom hole and the bottom edge of the part for the drawing in Figure 8-1

The overall height of the part, 1.950 – 2.050, has a zero perpendicularity tolerance at MMC to datum feature A. The worst-case boundaries of this dimension are the virtual and the resultant conditions. Convert the part height to an equal bilateral plus or minus tolerance.

2.050
1.950

⊥	.000 Ⓜ	A

Resultant Condition

1.950 Height @ LMC
- .000 Geo. Tol.
- .100 Bonus Tol.
1.850 Total

Virtual Condition

2.050 Height @ MMC
\+ .000 Geo. Tol.
2.050 Total

Result. Condition	2.050	2.050
Virtual Condition	+ 1.850	– 1.850
	2) 3.900	2) .200
	1.950	**.100**

The equal bilateral ± tolerance is: **1.950 ± .100**

The Ø.125 hole is located from the Ø.250 hole, datum feature B. Calculate the positional tolerance and the pattern shift of the Ø.250 hole at its LMC size.

Ø.250 ± .005

⌖	Ø.050Ⓜ	A	E	D
⌖	Ø.000Ⓜ	A		

Total positional tolerance

Positional tolerance equals	.050
Bonus at LMC equals	+ .010
Total positional tolerance at LMC equals	**.060**

Pattern shift:

The Ø.250 hole at LMC equals	.255
The virtual condition of datum feature B with respect to datum feature A equals	– .245
Pattern shift equals	**.010**
The sum of the positional tolerance and the pattern shift equals	**.070**

Since the Ø.125 hole is located to the Ø.250 hole, the worst-case boundaries consist of the resultant and virtual conditions of the Ø.125 hole combined with the positional tolerance and the pattern shift (.070) of the Ø.250 hole.

Ø.125 ± .005

⌖	Ø.000Ⓜ	A	BⓂ	CⓂ

Resultant Condition		**Virtual Condition**	
.130	Hole @ LMC	.120	Hole @ MMC
+ .000	Geo. Tol.	- .000	Geo. Tol.
+ .010	Bonus Tol.	.120	Total
.140	Total		
+ .070		– .070	
.210		**.050**	Pos. Tol. + Pattern Shift

Result. Condition	.210	.210
Virtual Condition	**+** .050	**–** .050
	2) .260	2) .160
	.130	**.080**

Dimension with ± tolerance = .130 ± .080
Dimension with ± tolerance/2 = **.065 ± .040**

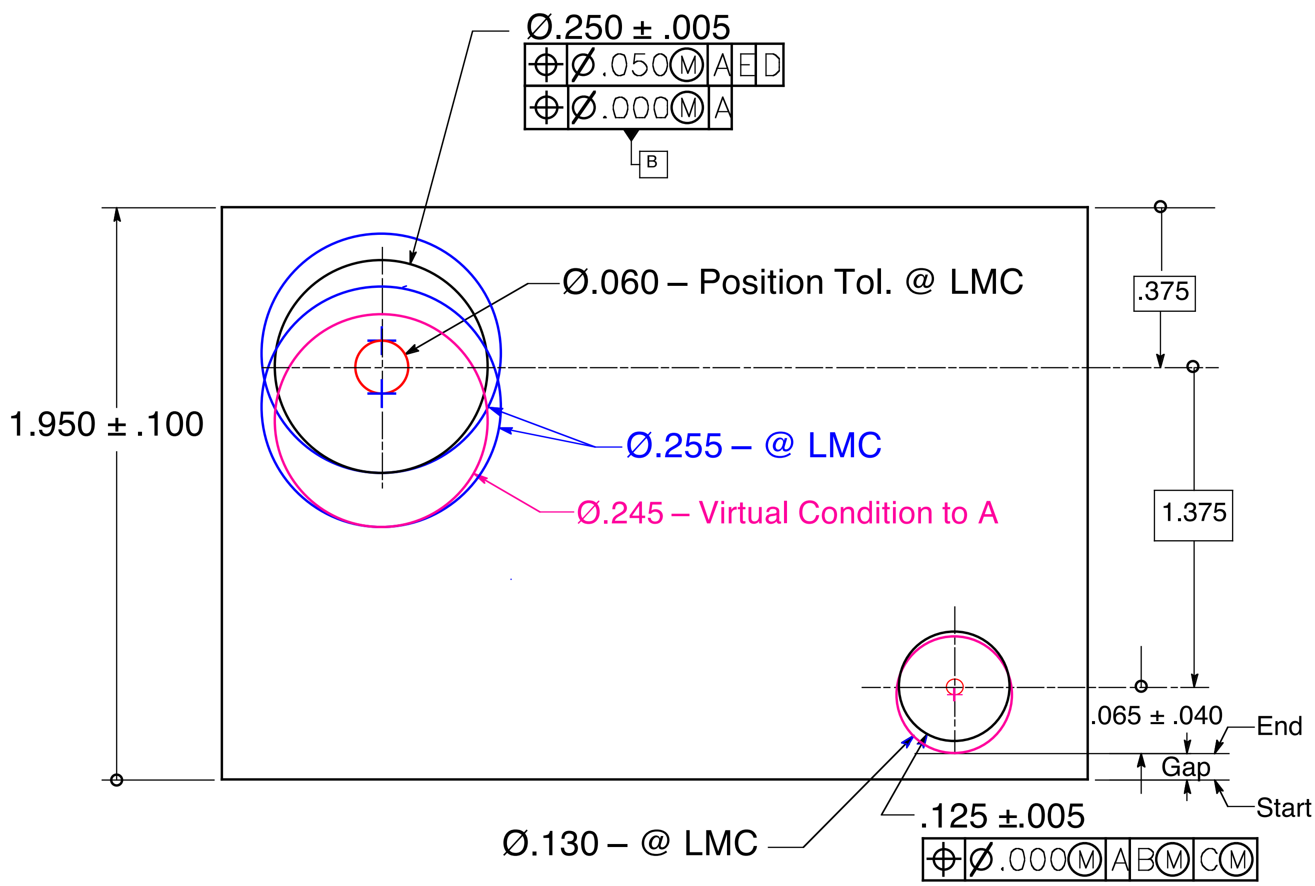

Figure 8-1B The loop analysis diagram with dimensions and tolerances

All of the positive and negative vectors are placed in the numbers chart. The positive vectors are dimensions that are measured from the bottom up and from the left to the right. The negative vectors are dimensions that are measured from the top down and from the right to the left. The tolerances are placed in the ± tolerance column. The vectors and the tolerances are totaled at the bottom. The sums of the vectors are added algebraically. The sum of the tolerances is added to, and subtracted from, the algebraic sum of all of the vectors to determine the MAX GAP and the MIN GAP.

Numbers Chart

Vectors		Tolerances
—	+	±
	1.950	.100
.375		.000
1.375		.000
.065		.040
– 1.815	+ 1.950	.140

Σ Of VECTORS	**MAX GAP**	**MIN GAP**
+ 1.950	+ .135	+ .135
– 1.815	+ .140	– .140
+ .135	**+ .275**	**– .005**

Although not a factor in this problem, it is possible that the rotation of the hole pattern controlled by datum feature C contributes to the gap dimensions. If that is the case, the rotation must be determined and the largest effect must be included in the analysis calculations.

Of the three steps in this analysis, step 2, drawing the loop analysis diagram, is the most critical and sometimes the most difficult to accomplish. It may take more than one try to determine the worst-case condition.