4x4 State Transition Criteria

First we define Drive pressure, *drivepress*, as the pressure in the compartment which drives eversion. This is compartment 1 for the 1-compartment model and compartment 2 for the 2-compartment model. We also define L_c, the length of material in the crumple zone between reel and everting portion as,

$$L_c = \theta r_{reel} - 2L \tag{1}$$

We then test some state variables to determine four boolean state transition conditions:

```
LoPress = drivepress < Pth1
HiPress = drivepress > Pth2
SlackExists = Lc > epsilon
noSlack =  Lc < epsilon
```

`LoPress` and `HiPress` determine when the eversion process stops and starts respectively. `SlackExists` and `noSlack` define conditions for when material crumples inside the housing between the reel and the eversion tube.

We then construct a table determining all transitions between the four possible states (Table 1).

To: / From:	Growing-Taut	Growing-Slack	Stuck-Taut	Stuck-Slack
	0	1	2	3
0		SlackExists	LoPress	LoPress **and** SlackExists
1	noSlack		LoPress **and** noSlack	LoPress
2	HiPress	HiPress **and** SlackExists		SlackExists
3	HiPress **and** noSlack	HiPress		

Table 1: 4x4 state transition diagram deterimining growing or stuck and taut or slack substates. State in each row makes transitions to column state when conditions in each cell are met. Blank cells indicating in the same state.

These state transitions are illustrated diagrammatically in Figure 1.

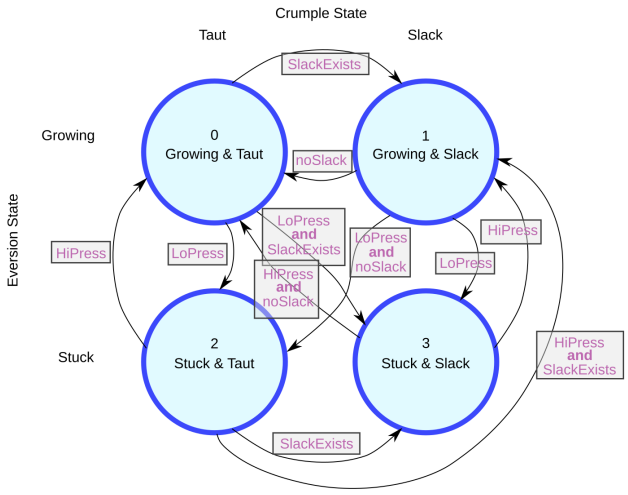

Figure 1:

1 Tubing Resistance

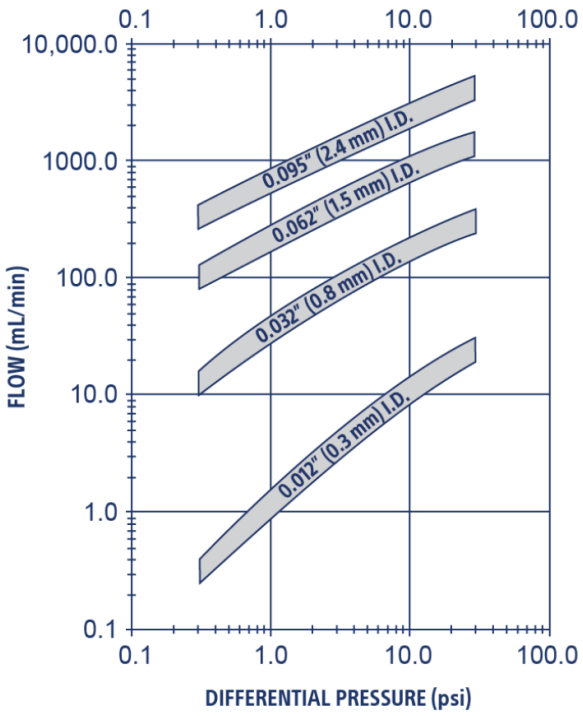

Figure 2: source: The Lee Company
`https://www.theleeco.com/support-resources/engineering-tools/reference-information/tubing-flow/`