



U.S. AIR FORCE



Abstract



In a recent study performed by the USAF, it appeared that if a neat fit fastener was installed in a hole that had a primary crack and a secondary crack, that the secondary crack was not influenced by the primary crack. To further investigate this finding a series of finite element models were created that varied crack size for the primary crack and secondary crack. Comparisons between models with and without secondary cracks are made to provide insight on how cracks, at a hole with a neat fit pin, may or may not influence each other.



Secondary Crack Influence in Holes with Fasteners

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Summary



- **Background**
- **Testing Metrix**
- **Model Parameters**
- **Model Loads and Constraints**
- **Mesh**
- **Convergence Factors**
- **Results**
- **Conclusion**



Background



In a recent study performed by the USAF, it appeared that if a neat fit fastener was installed in a hole that had a primary crack and a secondary crack, that the secondary crack was not influenced by the primary crack. To determine and quantify the interaction, this study was performed.



Test Matrix



Using StressCheck 10.5	Primary Crack	Secondary Crack
Cases to Study	0.050	0.005
1. Open Hole - Primary Crack Only	0.065	0.015
2. Open Hole - Secondary Crack Only	0.080	0.025
3. Open Hole - Primary and Secondary Combined	0.095	0.035
4. Filled Hole - Primary Crack Only	0.110	0.045
5. Filled Hole - Secondary Crack Only	0.125	0.055
6. Filled Hole - Primary and Secondary Combined	0.140	0.065
	0.155	0.075
	0.170	0.085
	0.185	0.095
	0.200	0.105
	0.215	0.115
	0.230	0.125



Model Parameters



Specimen

Length: 4 in

Width: 2 in

Thickness: 0.25 in

Neat Fit

Hole Diameter: 0.250 in

Pin Diameter: 0.250 in

Specimen Material

2024-T3511

E: $1.08\text{E}+07$ psi

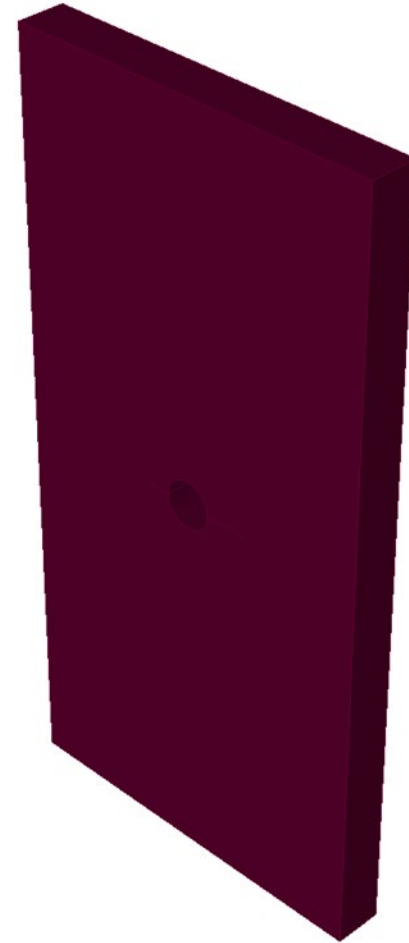
ν : 0.33

Pin Material

ASTM-A36

E: $2.90\text{E}+07$ psi

ν : 0.295





Loads and Constraints



Tensional Load

10000 lbs in -Y

Symmetric

Midway in specimen

Midway in pin

Pinned

Fixed in Z along backside

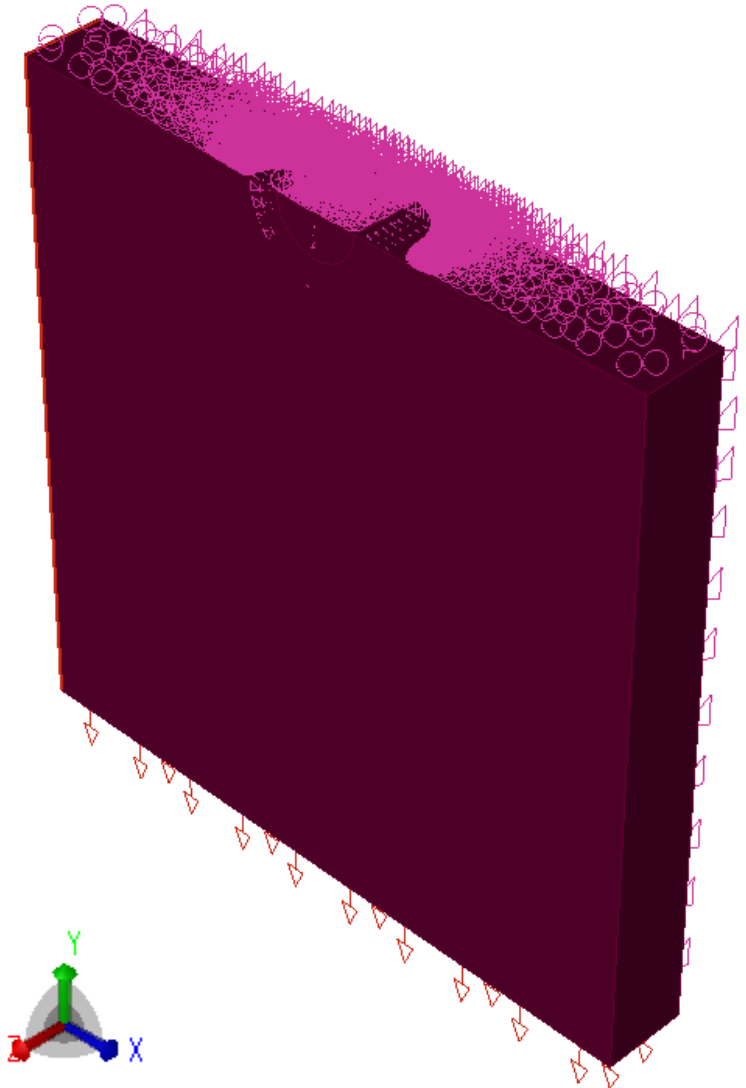
Contact Surface

Hole to pin interaction

Contact Constraint: $1.08E+06$

P-Level

P-Level: 4



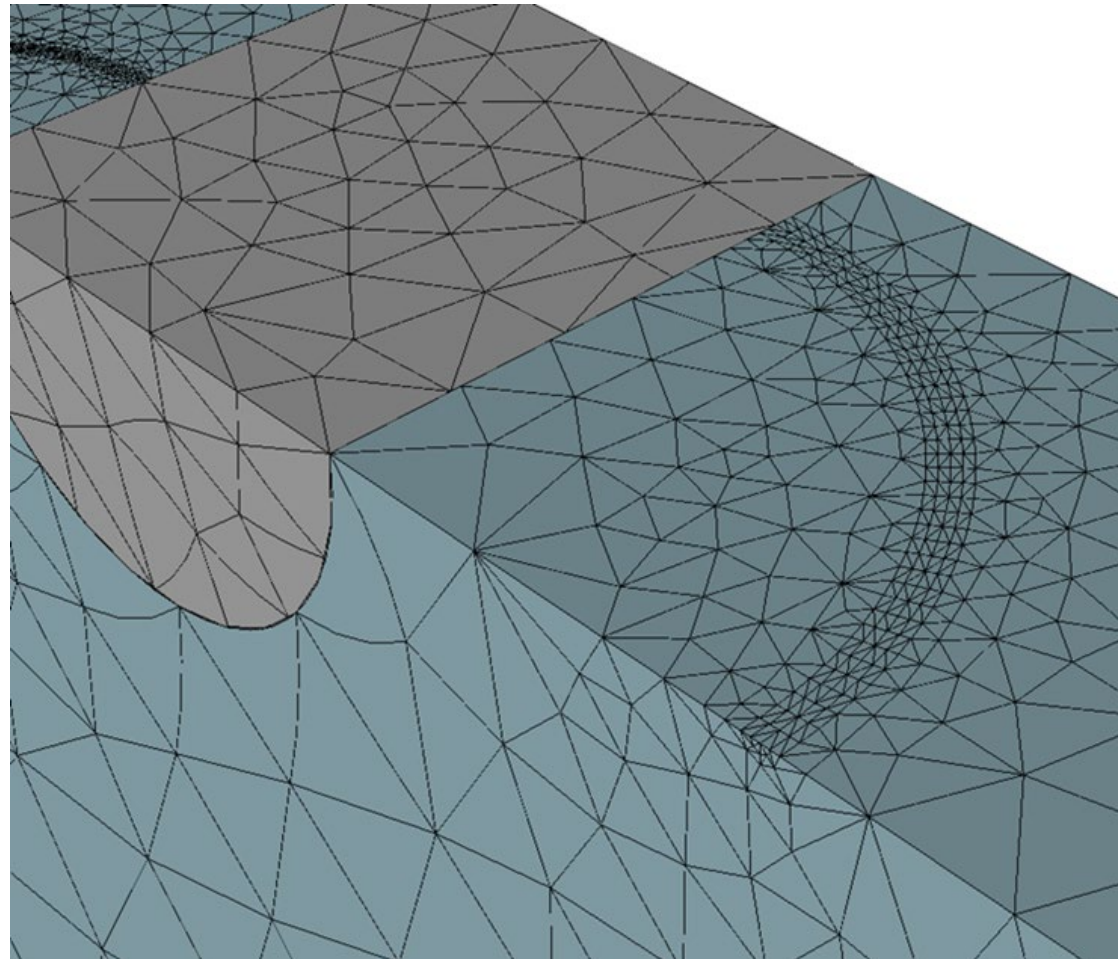


Mesh



- A-10 Ground Rules were used to mesh. (SIAG-2010-10884)
- Exceptions were made to the boundary layer at the crack front to achieve a workable mesh.
- Two boundary layers used and parameters adjusted until the element ratio was $\sim 1:2$

Ratio	0.016
Layers	2
To	$0.02 * Cr1$
T-total	$0.04 * Cr1$
Cr1	Radius of Primary Crack
Radius Integration	$0.03 * Cr1$





General Convergence Notes



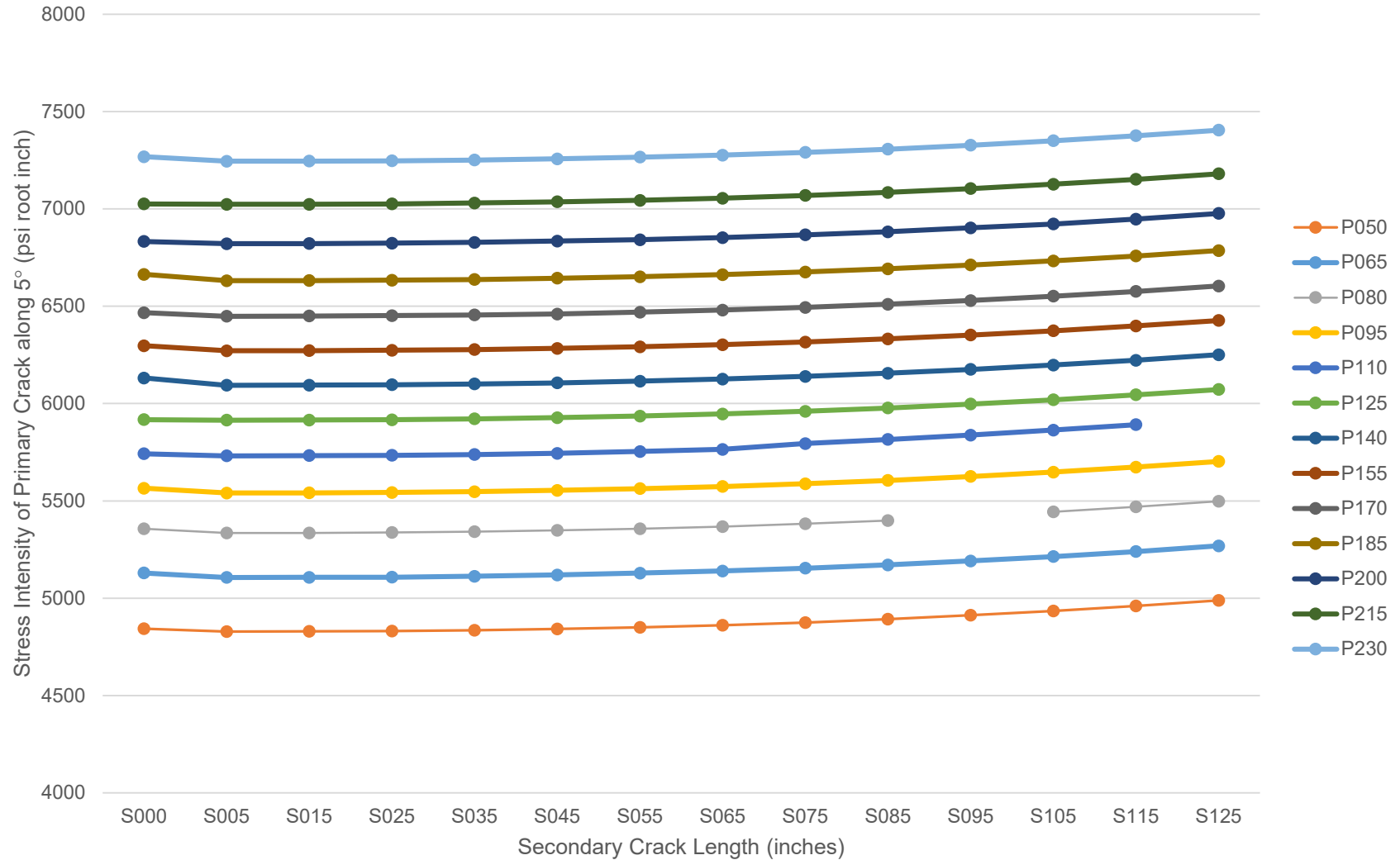
- Element ratio did not have a major impact on the stress intensity solution. Tested in the range of 1:1 to 1:4 with a maximum difference of 0.6% in K values. It should be noted that K values have difficulty being generated from elements with a high ratio in some models.
- Contact iteration did not have a major impact on the stress intensity solution. The minimum of 10 iterations resulted in around 5-7% maximum error and a difference of 0.5% in K values.
- Location of the Radius of Integration within the second element did not seem to follow a distinct pattern but differences were below 1.5%. Values of 0.01, 0.25, 0.50, and 0.75 into the second element were tested.
- Two and Three boundaries had minimal difference in K-values, with 0.8% difference in K values for the size used.
- T-total was the parameter used to achieve mesh convergence, with error being less than 1% to the next half sized elements. Meshes smaller than that used also introduced more error in the extreme elements of the crack front, probably due to singularities.



Stress Intensity - Fastener



Secondary Crack Influence on Primary Crack - Fastener

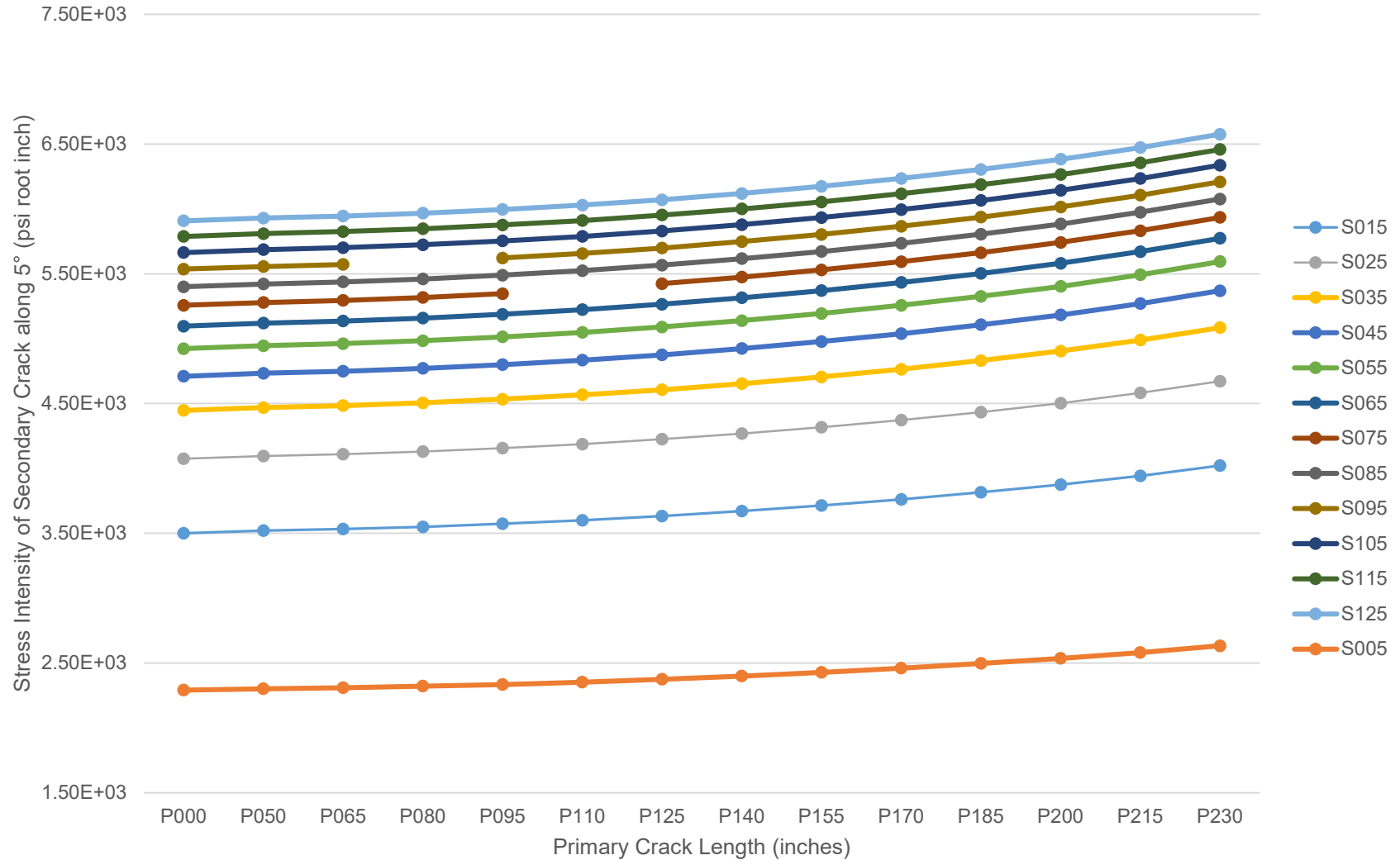




Stress Intensity - Fastener



Primary Crack Influence on Secondary Crack - Fastener

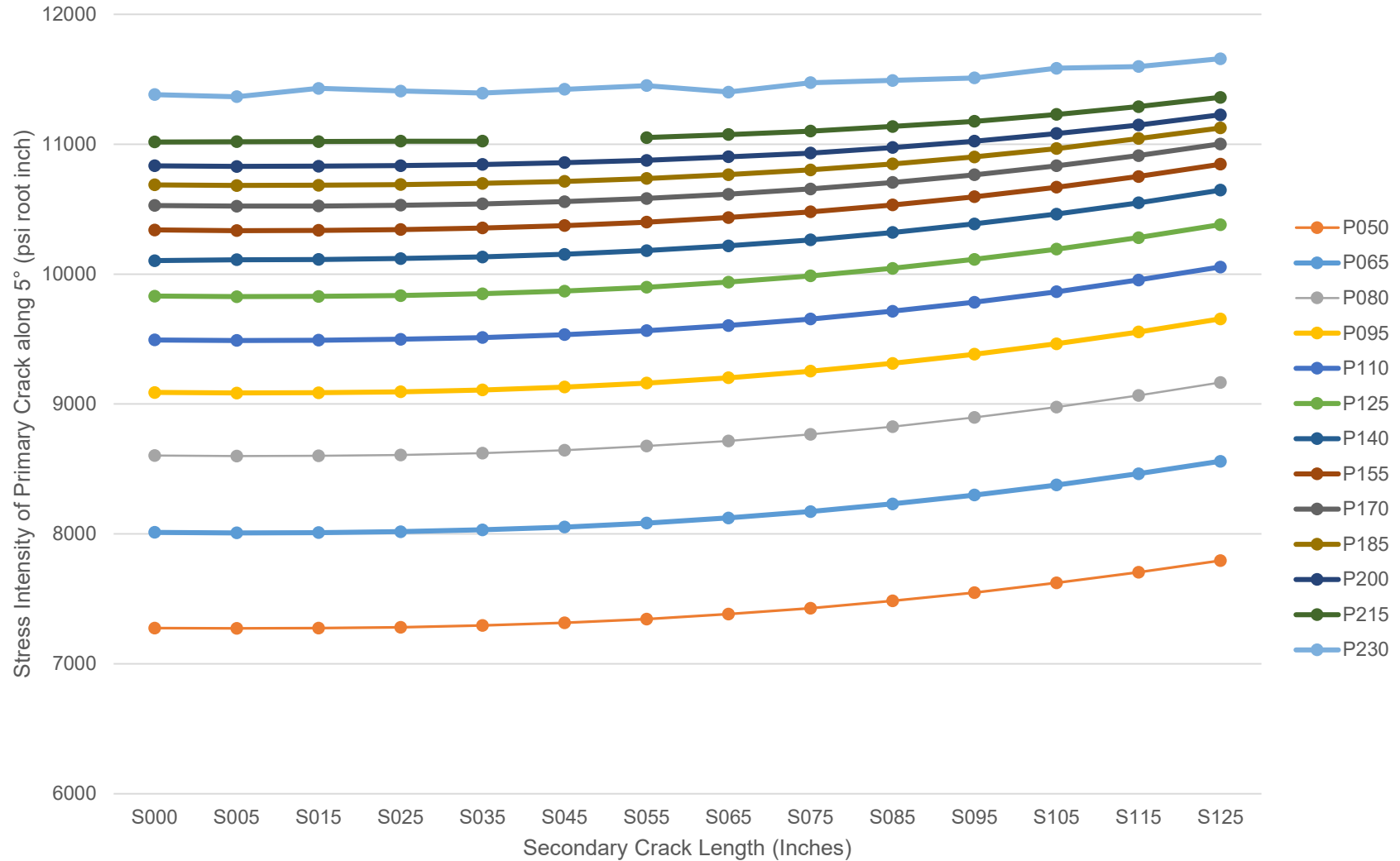




Stress Intensity - Open



Secondary Crack Influence on Primary Crack - Open

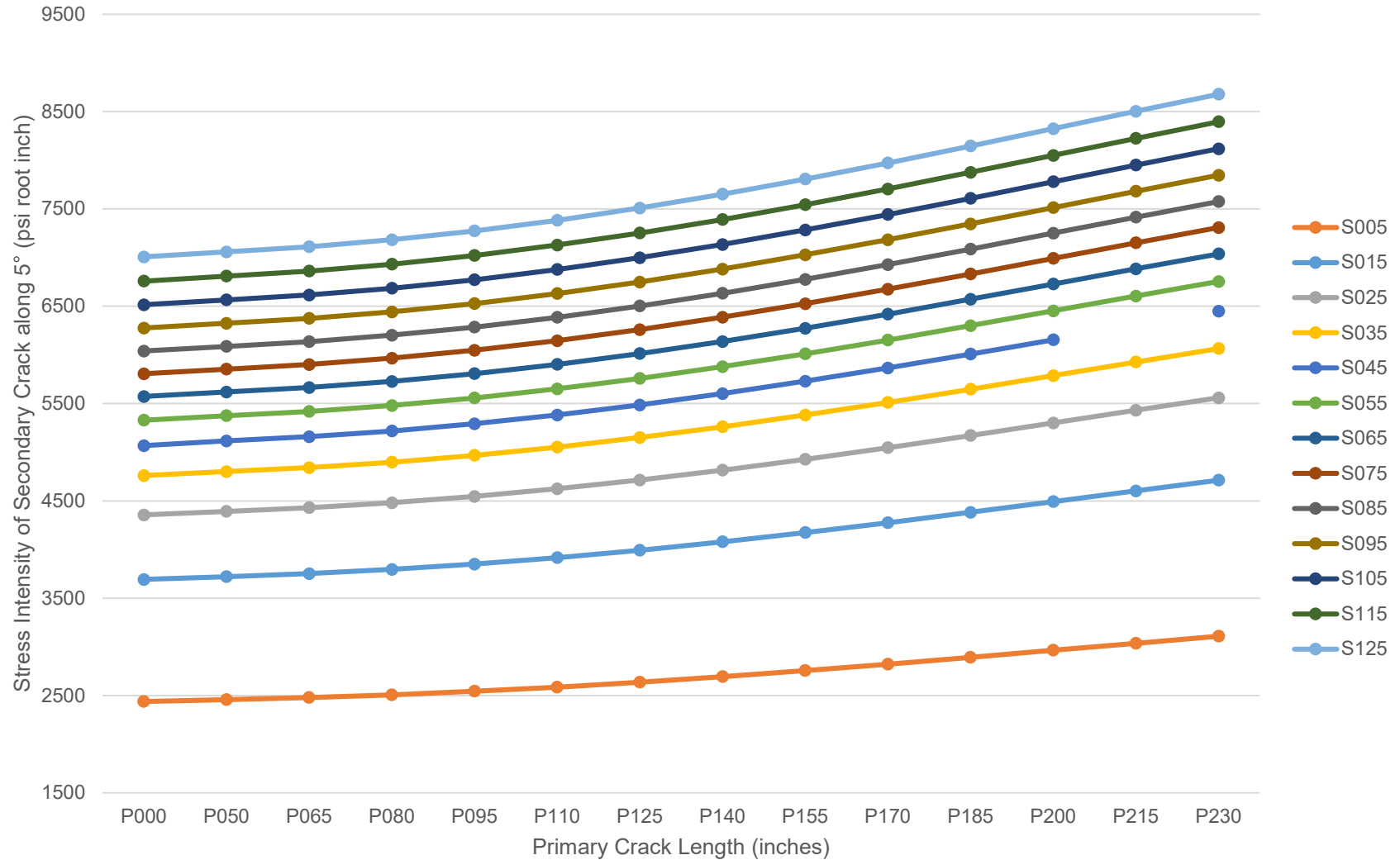




Stress Intensity - Open



Primary Crack Influence on Secondary Crack - Open

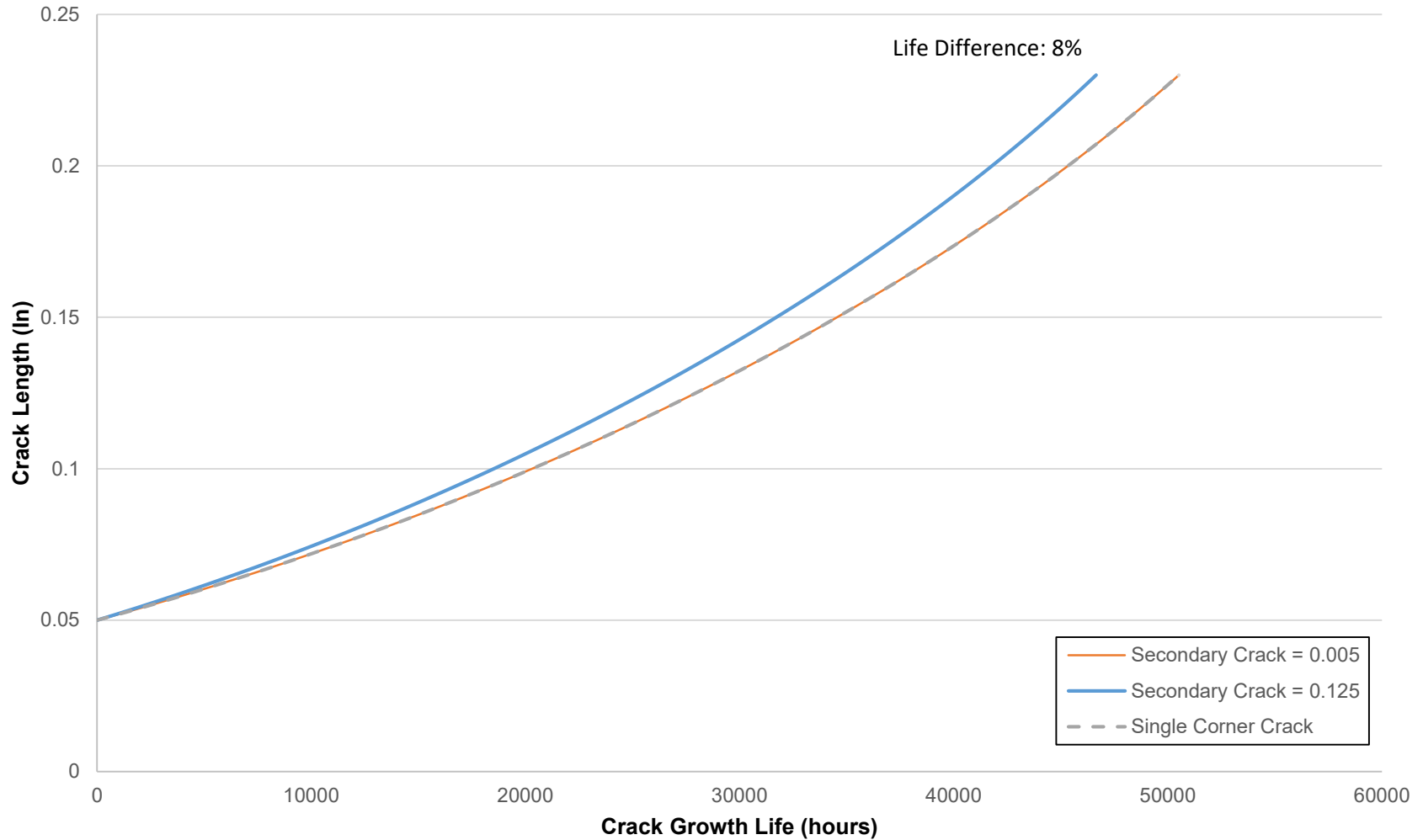




Growth Curve - Fastener



Primary Crack held Constant at 0.005" & 0.125
Secondary Crack Growth Curve

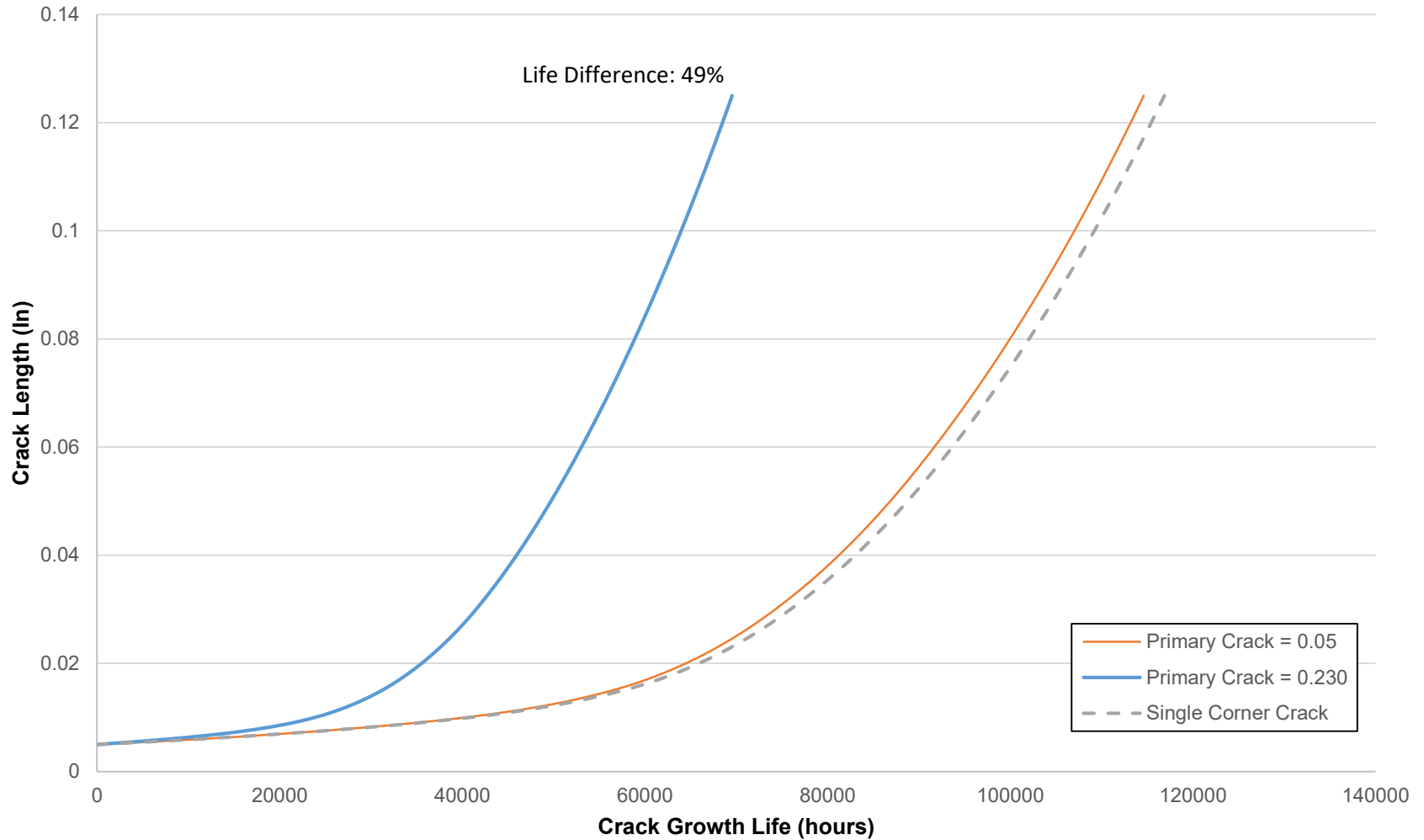




Growth Curve - Fastener



Primary Crack held Constant at 0.05" & 0.230
Secondary Crack Growth Curve

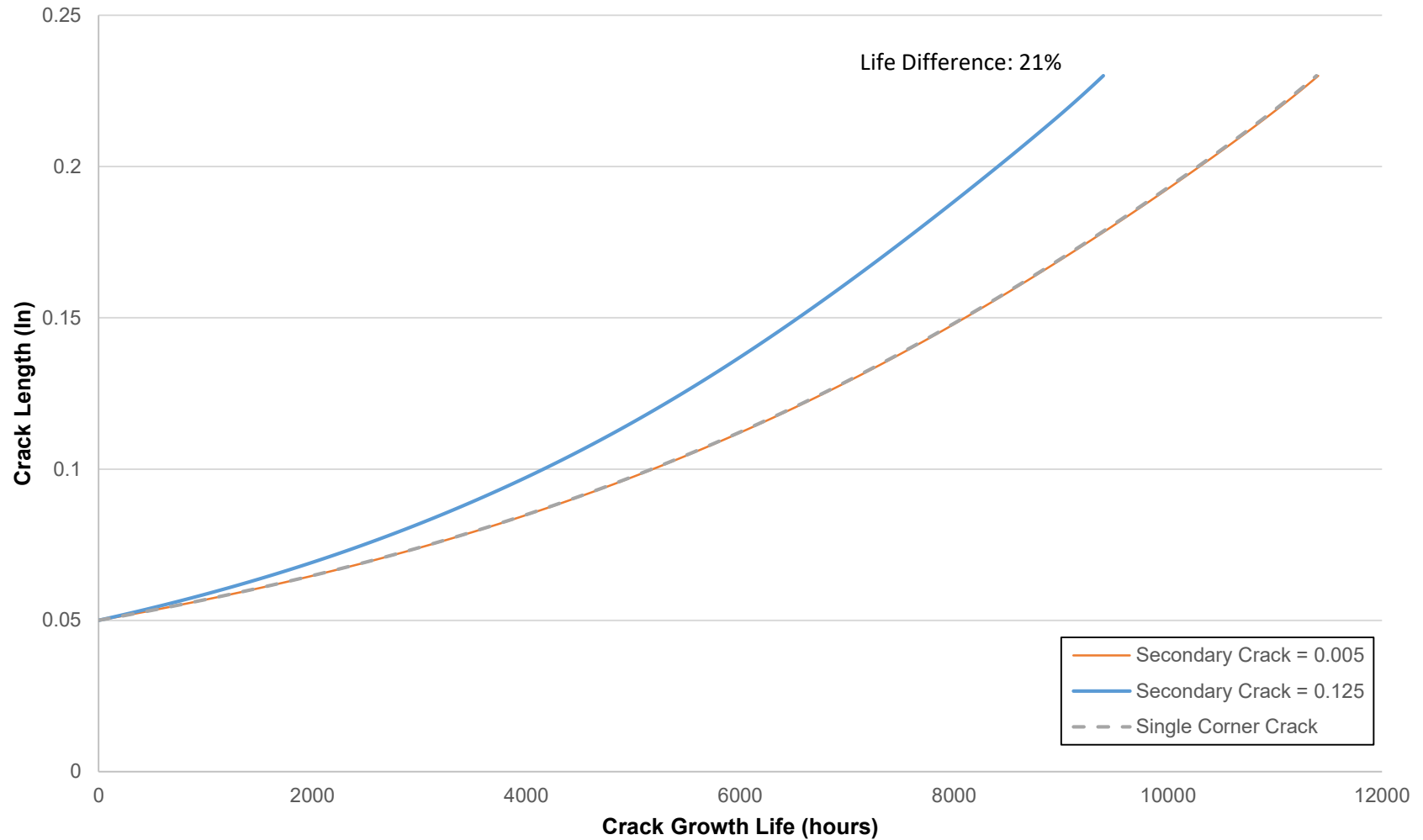




Growth Curve - Open



Primary Crack held Constant at 0.005" & 0.125
Secondary Crack Growth Curve

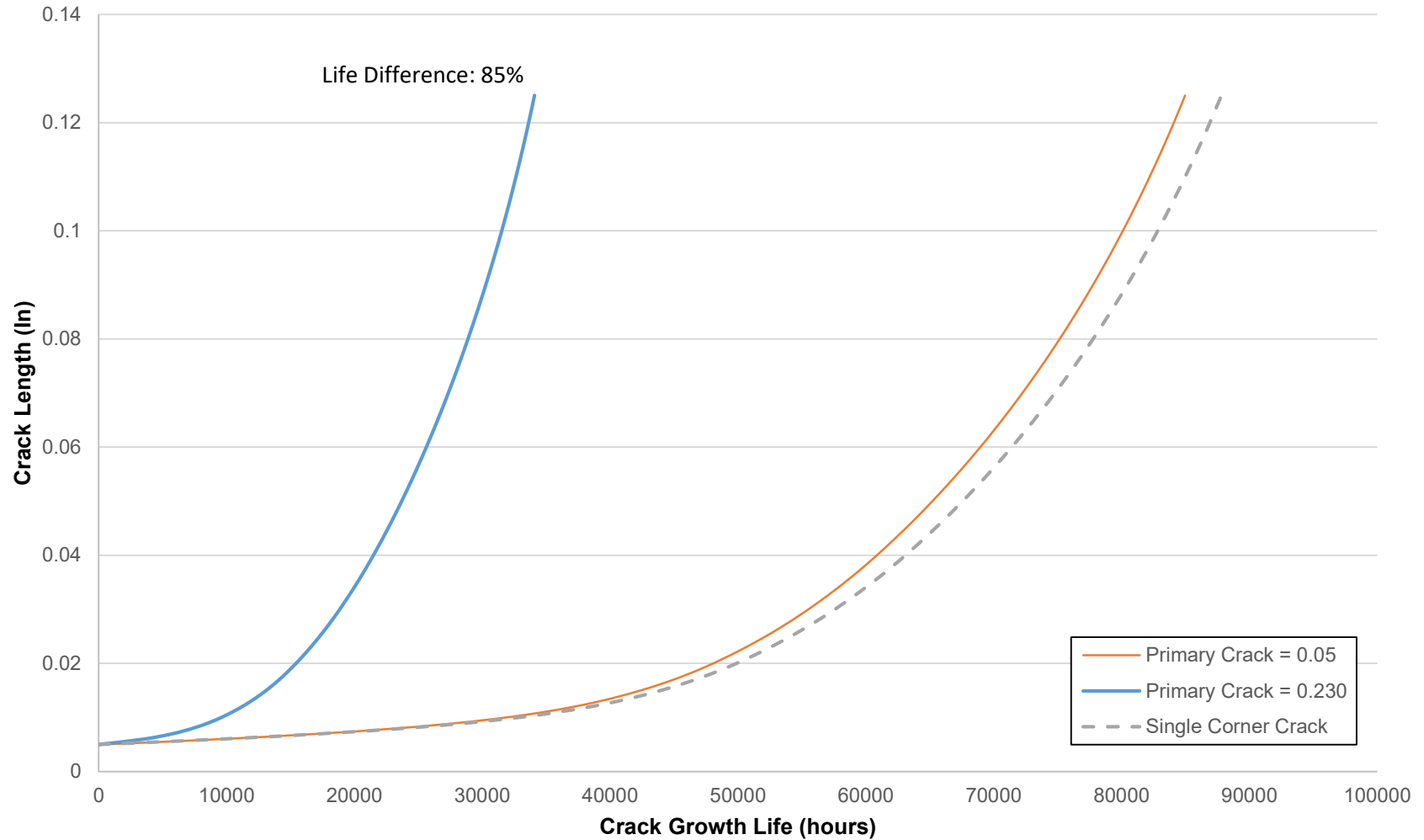




Growth Curve - Open



Primary Crack held Constant at 0.05" & 0.230
Secondary Crack Growth Curve





Questions?