## **Table of Contents**

Section	n	Pa	ge No.
1.0	INTRO	DDUCTION	1
2.0	BACK0 2.1 2.2	GROUND	1 2 2 3
3.0	TEST F 3.1 3.2	PROCEDURE  Nondestructive Testing  Destructive Analysis	6
4.0	RESUL 4.1 4.2 4.3	TS  Detectability  Flaw Sizing (Comparison with Etching Procedure)  EDM Results	18 19
5.0	CONC	CLUSIONS AND RECOMMENDATIONS	34
Apper	ndix B:	Glossary of Terms Bryant-Lee Associates Data Report on EDM and Measurement of Cracks o Aluminum Cylinder Samples Data Sheets	n
		List of Figures	
Figure	No.	Pa	ge No.
2-1		ation of the Site of Crack Initiation and its Propagation through the	2
2-2	-	uipment used to Visually Inspect the Compressed Gas Cylinders s Project	2
2-3		ation of the Flaw with Respect to the Eddy Currents has a Direct g on the Detection of the Flaw	3
2-4	Eddy C	Current Equipment used in the Project	4
2-5	Closeu	ıp of an Eddy Current Probe	4

2-6	UT Inspection System, Consisting of One Pitch and One Catch Probe Inside a Fluid-Filled Wheel	5
2-7	Example of a UT Inspection In Progress	5
3-1	Illustration of the Test Progression Used in the Project	7
3-2	Each Cylinder Head was Cut to Isolate the Cracks of Interest	9
3-3	The Apparatus used to Break Open the Cracks in a Cylinder Head	10
3-4	Close up View of the Crack Opening Procedure	10
3-5	Screen Shot of the Java Application ImageJ Produced by NIH, being used to Find the Cross-sectional Area of a Crack in a SCUBA Cylinder	11
3-6	Measuring the Extent of a Crack. The highlighted region shows the approximate extent of the crack along the line in the upper left image	12
3-7	Photographs of the Red-Dye Penetrant Indication for (A) Cylinder Samples T94863 and (B) P4205. Arrows indicate cracks.	14
3-8	Sketch Showing how the EM Wafers were Taken	15
3-9	Photographs of Cylinder Sample T94863 and P4205 Showing (a) the OD Surface and (b) the ID Surface	16
3-10	EDM Set-Up for Cylinder Sample	17
4-1	Reported Flaw Size for the Crack in SCUBA Cylinder P157756 for Each Inspection	22
4-2	Average Flaw Sizes for the Crack in P157756 for Technique and Skill Level	22
4-3	Reported Flaw Size for the Crack in SCUBA Cylinder P16297 for Each Inspection	23
4-4	Average Flaw Sizes for the Crack in P16297 for Technique and Skill Level	23
4-5	Reported Flaw Size for the First Crack in SCUBA Cylinder P101050 for Each Inspection	24
4-6	Average Flaw Sizes for the First Crack in P101050 for Technique and Skill Level	24

4-7	Reported Flaw Size for the Second Crack in SCUBA Cylinder P101050 For Each Inspection	25
4-8	Average Flaw Sizes for the Second Crack in P101050 for Technique and Skill Level	25
4-9	Reported Flaw Size for the First Crack in SCBA Cylinder T58636 for Each Inspection	26
4-10	Average Flaw Sizes for the First Crack in T58636 for Technique and Skill Level	26
4-11	Reported Flaw Size for the Second Crack in SCBA Cylinder T58636 for Each Inspection	27
4-12	Average Flaw Sizes for the Second Crack in T58636 for Technique and Skill Level	27
4-13	Mean Absolute Discrepancy (MAD) Results by Inspection	28
4-14	Mean Absolute Discrepancy (MAD) Results by Technique and Skill Level	28
4-15	Production of the UT Calibration Curve	30
4-16	Photomicrographs of the (a) apparent Crack Tip at 0.490-inch from Bore ID and (b) Crack Tip Region at 0.665-inch from Bore ID for Wafer A5	33
5-1	Summary of the Test Results, Plotting Each Technique's Mean Absolute Discrepancy (MAD) Against it's Reliability Index (RI). An ideal technique would be plotted at the origin (0,0), representing a technique that has no false calls and that perfectly sizes every flaw it detects.	36
5-2	Average Performances Across Technique and Skill Level. As in Figure 5-1 the ideal case is to be at the origin (0,0).	36
	List of Tables	
Table	Page ?	No.
3-1	Nine Different NDT Inspections were Conducted for each of the 51 Cylinders	6
4-1	Summary of Results Using an Angular Width of ±20°	18
4-2	Summary of Results Using an Angular Width of ±30°	19

4-3	Cylinders Chosen for the Flaw Sizing Analysis	20
4-4	Summary of the Flaw Sizing Study	21
4-5	Example of the Aspect Ratios Seen During the Flaw Sizing Study	30
4-6	Wafer Location and Crack Depth for T94863	31
4-7	Wafer Location and Crack Depth for P4205	32
4-8	Reported Flaw Size for the Flaw in SCBA Cylinder T94863, for Which the Actual Flaw Size is Approximately 14 Threads	34
4-9	Reported Flaw Size for the Flaw in SCBA Cylinder T94863, for Which the Actual Flaw Size is Approximately 14 Threads	34