How to use the CINDAS LLC on-line handbooks

Introducing the Damage Tolerant Design Handbook
in PDF format.

Photo by Ross Parmly on Unsplash

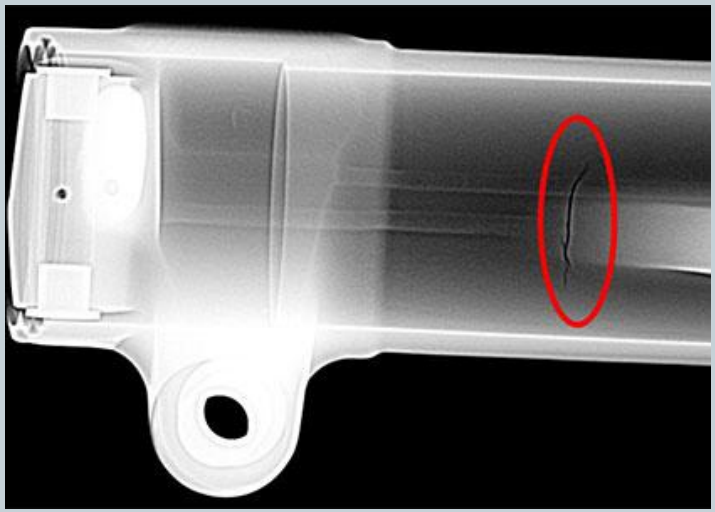
Materials Properties

- Change with Temperature
  - Strength, ductility
  - Dimensions: expansion, contraction
- Some properties change with Use
  - Fatigue life

- People who design structures (cars, airplanes, bridges, ships, turbines, oil infrastructures, etc.) not only need reliable materials data to pick the right material for the application, they also need reliable data to monitor and make decisions while the application is in use.

Damage Tolerant Design Handbook

- Five volume, 3600 pages
- Compiled by Materials Directorate WPAFB
- Comprehensive compilation
  - Fracture
  - Crack growth
- Mechanical properties data
  - Design
  - Analysis



Structural Failures with Comet Aircraft

BOAC Flight 781

A BOAC de Havilland Comet 1 similar to accident aircraft

Accident summary	
Date	10 January 1954
Summary	In-flight metal fatigue failure leading to explosive decompression and mid-air break-up.
Site	Mediterranean Sea off Elba
Passengers	29
Crew	6
Fatalities	35 (all)
Survivors	0
Aircraft type	de Havilland DH-106 Comet 1
Aircraft name	Yoke Peter
Operator	British Overseas Airways Corporation
Registration	G-ALYP
Flight origin	Kallang Airport, Singapore
Stopover	Ciampino Airport, Rome, Italy
Destination	London Heathrow Airport, London, England

Fatigue listed as cause

1988 – Aloha Airlines (Hawaii)

35 years after the Comet crashes

- A 19-year old Boeing 737 suffered an explosive decompression when a large portion of the upper fuselage structure broke off at altitude. This was a fracture toughness failure since the structure failed suddenly under load.
- The plane had experienced 89,090 take-offs and landings with significant fatigue cracks present in the fuselage. The cracking was made worse by corrosion due to the sea atmosphere.
- Although the plane was able to land and 94 out of 95 people survived, appropriate use of fracture toughness and crack growth predictive data (as in the DTDH) may have prevented the occurrence.

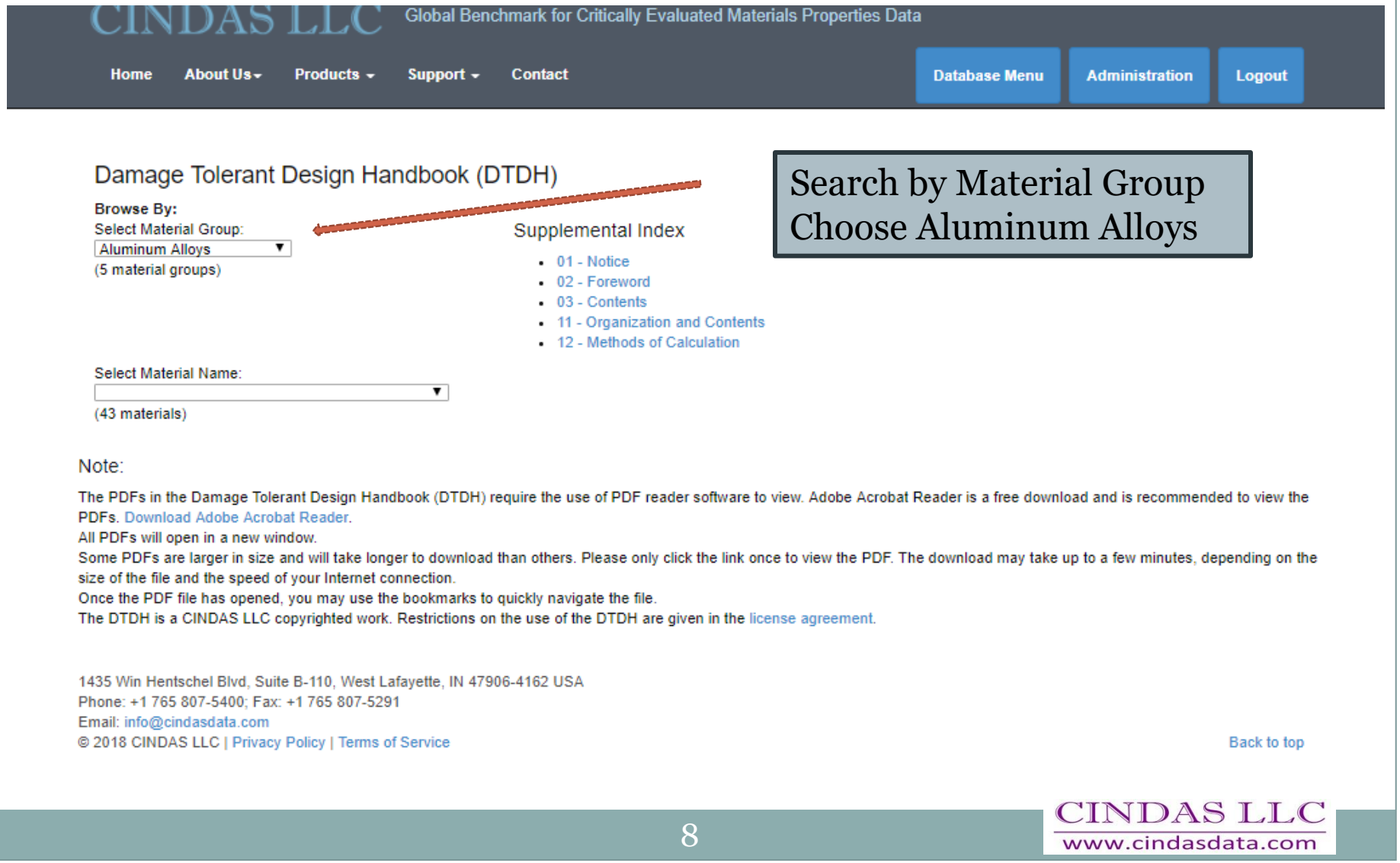
Each Alloy Section contains

- Fracture toughness
- Crack growth
- R-curve
- Sustained load
- Threshold data

- Stainless steels
- Alloy steels
- Nickel based super alloys
- Titanium alloys
- Aluminum 2000/6000 alloys
- Aluminum 7000/8000 alloys

Organization of data

- Suggested by aerospace engineers
- Matches other handbooks like MMPDS and ASMH, now ASMD
- Mean trend fatigue crack growth and sustained crack growth data on same page as plots of crack growth rate data
- Root mean square percent error and life prediction ratio on same page, if available



Search by Material Group
Choose Aluminum Alloys

CINDAS LLC Global Benchmark for Critically Evaluated Materials Properties Data

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Damage Tolerant Design Handbook (DTDH)

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(5 material groups)

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- 01 - Notice
- 02 - Foreword
- 03 - Contents
- 11 - Organization and Contents
- 12 - Methods of Calculation

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(43 materials)

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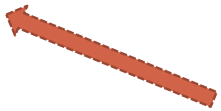

Of 43 Aluminum Alloys, select 2024

Note:

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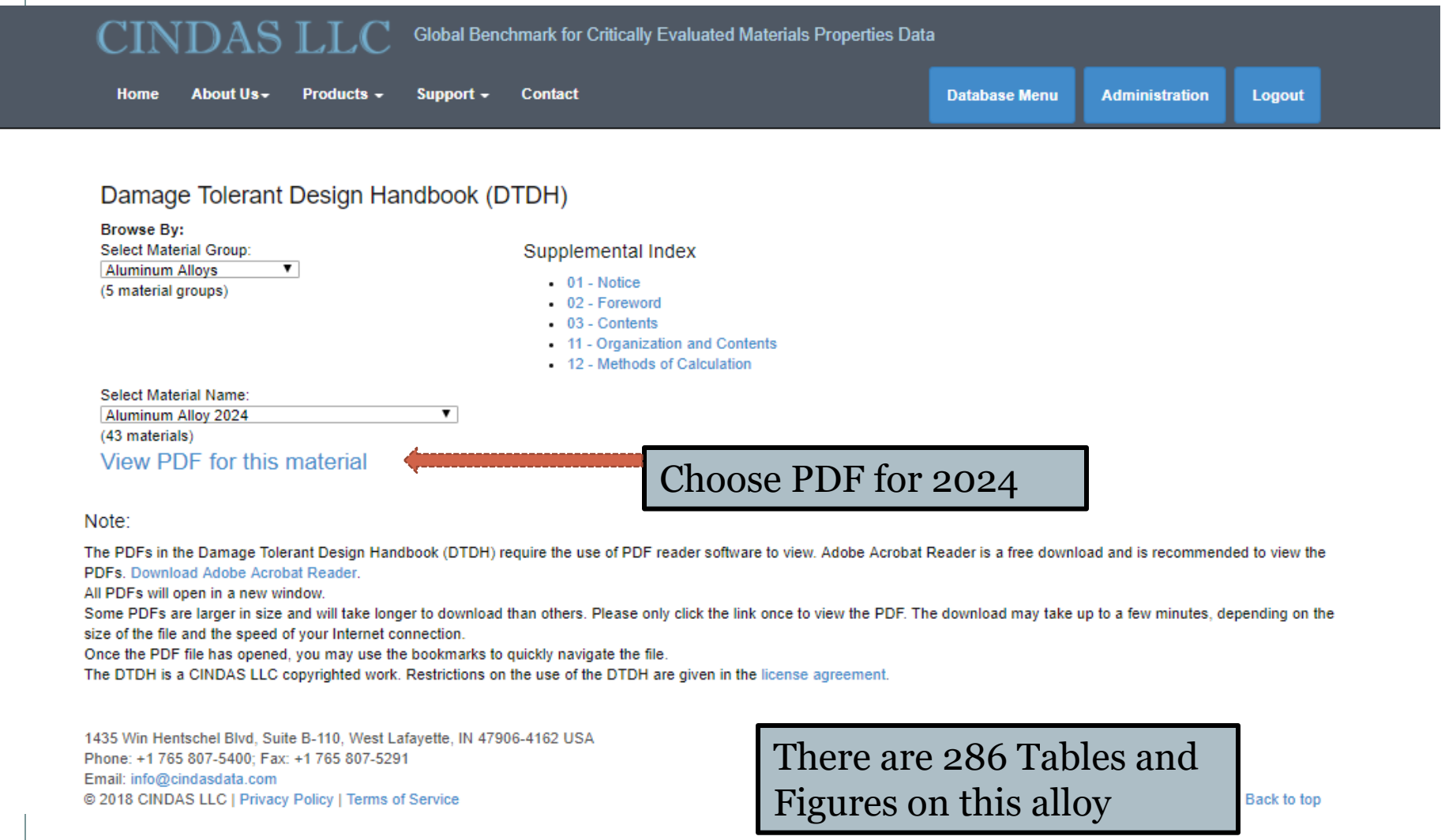
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There are 286 Tables and Figures on this alloy
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Multitude of damage tolerance data

- All Tempers for 2024 manufactured products
- Many environments
  - Laboratory air
  - Distilled water
  - 3.5% Sodium chloride
- Data for various forms
  - Sheet
  - Plate
  - Extrusions
  - Forgings

Fatigue Crack Growth Rate- distilled water

TABLE 7.5.1.2.13

FATIGUE CRACK GROWTH RATE AT DEFINED LEVELS OF STRESS INTENSITY FACTOR ΔK
2024 AT ROOM TEMPERATURE

ORIENTATION: T-L **ENVIRONMENT: Distilled Water**

CONDITION/ HEAT TREATMENT	PRODUCT FORM	R	FREQ (Hz)	FCGR (10^{-6} in/cycle) ΔK Level (Ksi√in)					
				2.5	5.0	10.0	20.0	50.0	100.0
T3	SHEET	0.05	1			5.5	53.56		
		0.05	1-5			3.48	39.11		
		0.8	1		0.91				
		0.8	1-5	0.28	1.47				

Fatigue Crack Growth Rate- dry air

TABLE 7.5.1.2.14

FATIGUE CRACK GROWTH RATE AT DEFINED LEVELS OF STRESS INTENSITY FACTOR ΔK
2024 AT ROOM TEMPERATURE

ORIENTATION: T-L **ENVIRONMENT: Dry Air**

CONDITION/ HEAT TREATMENT	PRODUCT FORM	R	FREQ (Hz)	FCGR (10^{-6} in/cycle) ΔK Level (Ksi√in)					
				2.5	5.0	10.0	20.0	50.0	100.0
T62	SHEET	0.1	6		0.8	11.85			
		0.3	6		0.68	11.37			
		0.5	6	0.05	0.94	14.87			
T81	SHEET	-0.25	6			3.63	48.23		
		0.08	6			4.3	74.54		
		0.1	6			3.53			
T851	PLATE	0.08	1			5.9			
		0.08	6			9.54			

Fatigue Crack Growth Rate –S.T.W

TABLE 7.5.1.2.17

FATIGUE CRACK GROWTH RATE AT DEFINED LEVELS OF STRESS INTENSITY FACTOR ΔK 2024 AT ROOM TEMPERATURE

ORIENTATION: T-L **ENVIRONMENT: S.T.W.**

CONDITION/ HEAT TREATMENT	PRODUCT FORM	R	FREQ (Hz)	FCGR (10^{-6} in/cycle) ΔK Level (Ksi√in)					
				2.5	5.0	10.0	20.0	50.0	100.0
T62	SHEET	-0.25	1		0.97	5.33			
		0.1	1		0.82	5.86			
		0.3	1		1.3	16.22			
		0.5	1	0.11	2.5	25.44			
T81	SHEET	0.08	1			6.85	98		
		0.1	1		0.36	7.39	130.7		
T852	FORGING	0.08	1			5.19			

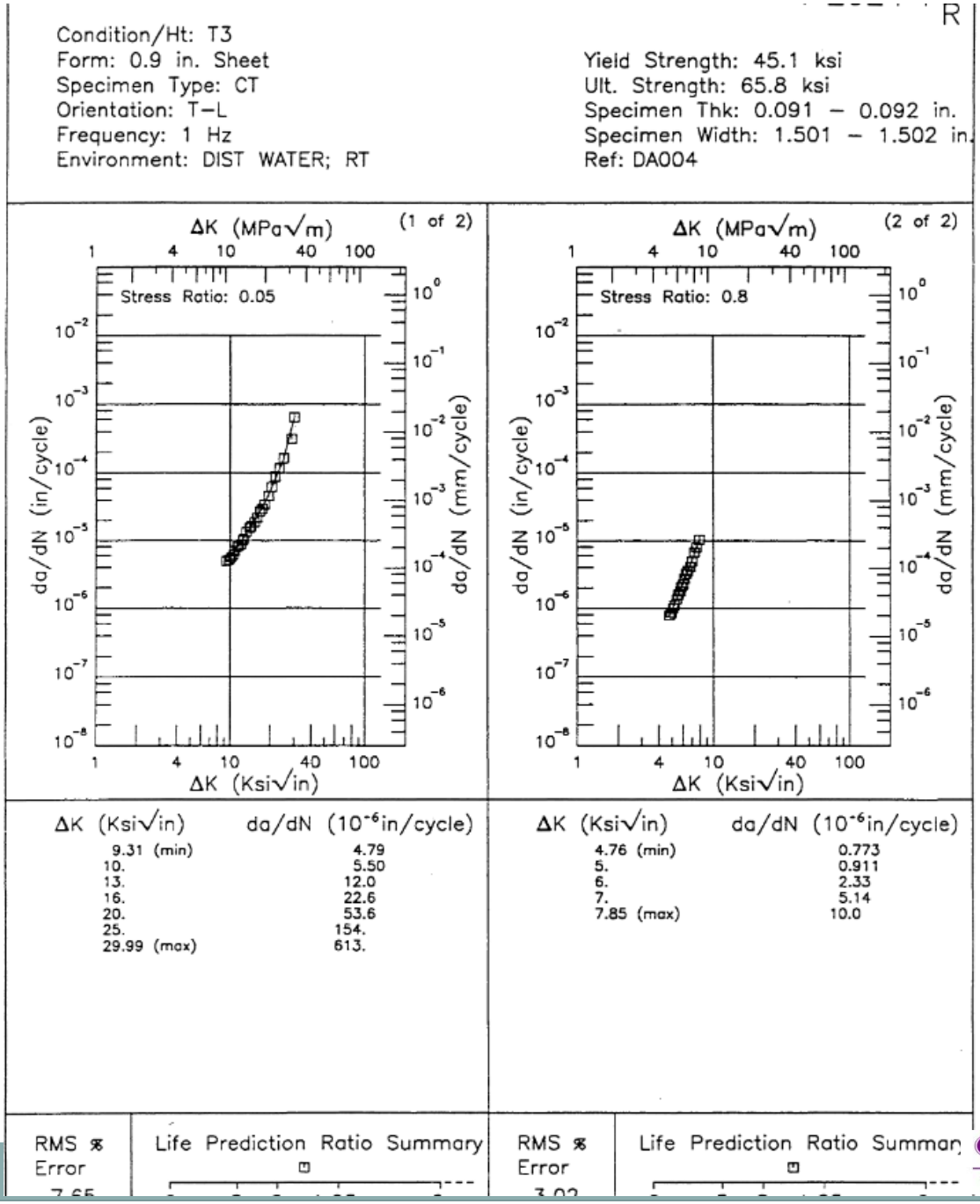
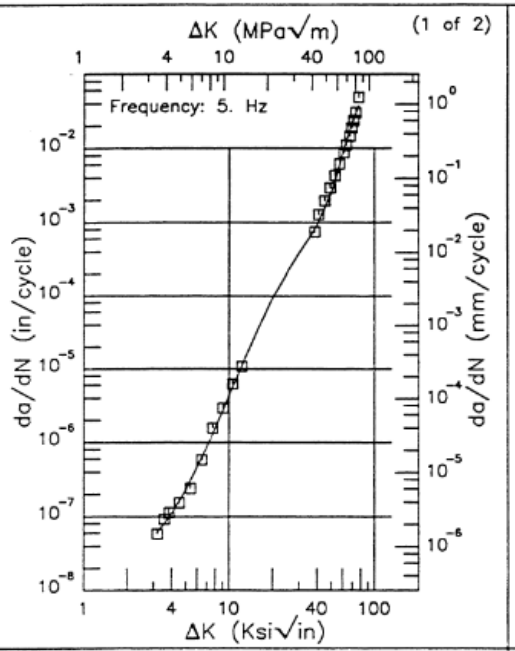


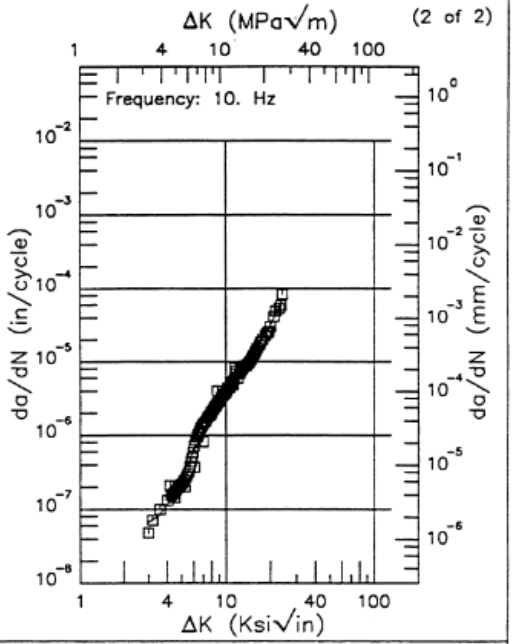
Figure 7.5.3.1.6 da/dN vs. ΔK for sheet in distilled water

2024 F

Condition/Ht: T3
Form: 0.9 in. Sheet
Specimen Type: CCP (max load specified)
Orientation: L–T
Stress Ratio: 0.05
Environment: LAB AIR; RT

Yield Strength: 15–52.5 ksi
Ult. Strength: 67.5 ksi
Specimen Thk: 0.089 in.
Specimen Width: 12.009–12.01 in.
Ref: DA004;DA005





ΔK (Ksi√in)	da/dN (10^{-6}in/cycle)
3.17 (min)	0.0614
3.5	0.0767
4.	0.110
5.	0.229
6.	0.460
7.	0.875
8.	1.57
9.	2.67
10.	4.34
16.	36.8
20.	94.0
30.	387.
40.	947.
60.	8309.
77.51 (max)	37569.

ΔK (Ksi√in)	da/dN (10^{-6}in/cycle)
2.97 (min)	0.0669
3.	0.0672
3.5	0.0823
4.	0.117
5.	0.269
6.	0.599
7.	1.18
8.	2.01
9.	3.01
10.	4.10
13.	7.96
16.	13.7
20.	31.2
24.00 (max)	69.2

RMS % Error 14.23

Life Prediction Ratio Summary
0. .5 .8 1.25 2.

RMS % Error 14.00

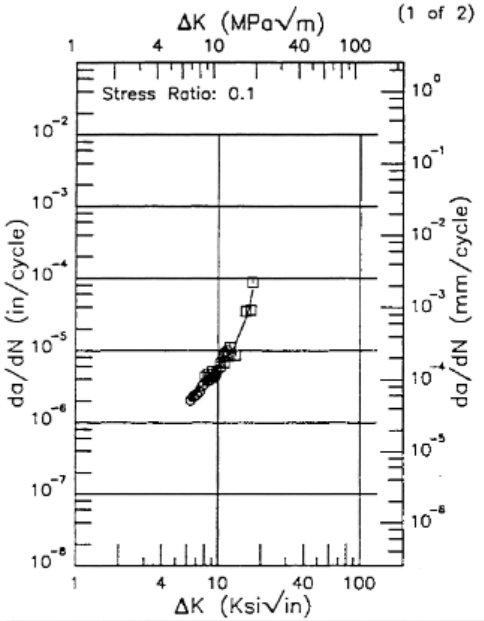
Life Prediction Ratio Summary
0. .5 .8 1.25 2.

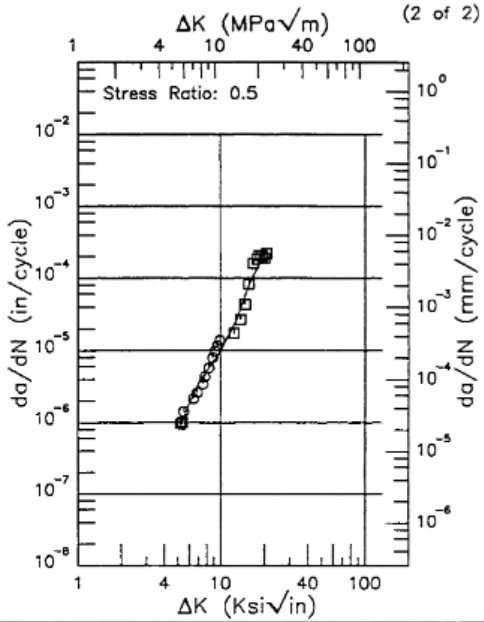
Figure 7.5.3.1.10 da/dN vs. ΔK for sheet in lab air

R

Condition/Ht: T851
Form: 0.75 – 0.76 in. Plate
Specimen Type: PTSF (max stress specified)
Orientation: T–S
Frequency: 20 Hz
Environment: 3.5% NACL; RT

Yield Strength: 70.1 ksi
Ult. Strength: 73.5 ksi
Specimen Thk: 0.759 – 0.763 in.
Specimen Width: 5 – 5.005 in.
Ref: 90981





ΔK (Ksi√in)	da/dN (10^{-6}in/cycle)
6.40 (min)	1.94
7.	2.50
8.	3.47
9.	4.52
10.	5.71
13.	11.2
16.	32.4
17.38 (max)	68.8

ΔK (Ksi√in)	da/dN (10^{-6}in/cycle)
5.20 (min)	0.854
6.	1.85
7.	3.43
8.	5.21
9.	7.28
10.	9.89
13.	26.8
16.	82.6
20.	229.
20.75 (max)	254.

RMS % Error	Life Prediction Ratio Summary
16.38	0. .5 .8 1.25 2.

RMS % Error	Life Prediction Ratio Summary
23.66	0. .5 .8 1.25 2.

Figure 7.5.3.1.113 da/dN vs. ΔK for sheet in 3.5% NaCl

"outstanding reference source in all failure analyses"

"Engineers working in metals and alloys across all six laboratories utilized the CINDAS data on a daily basis and considered it the most valuable and effective technical data at our disposal."

John Yadon who served as a metallurgical engineer and National Division Head for NAVAIR for over 34 years recently commented on the value of the CINDAS materials properties databases and their unique benefits and features

Questions?

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- Questions later can always be sent to us
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  - rob@cindasdata.com or
  - patti@cindasdata.com