

# Pyrotechnic Based Aircraft Escape Systems: Underwater Risks.

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# 01 Introduction

## The problem

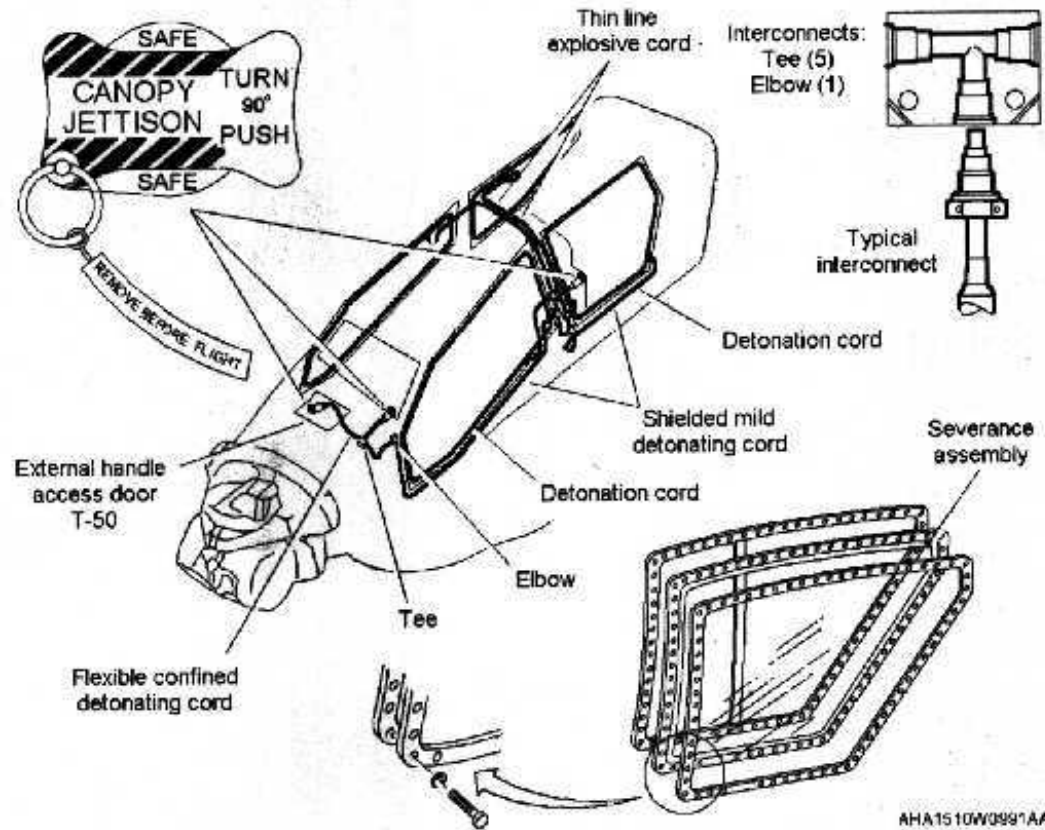
- Effect of water immersion on the AH pyrotechnic Canopy Jettison System (CJS)
- Safe for flight over water
- Function of system
- Noise levels

## 02 Description of the AH CJS

- The CJS uses a mild detonator cord (MDC)
  - laced around the perimeter of the four acrylics
    - CPG door and window
    - Pilot door and window
  - Turning any of the three initiator handles will fire the entire system
    - CPG
    - Pilot
    - External



# 03 Description of the AH CJS - Schematic

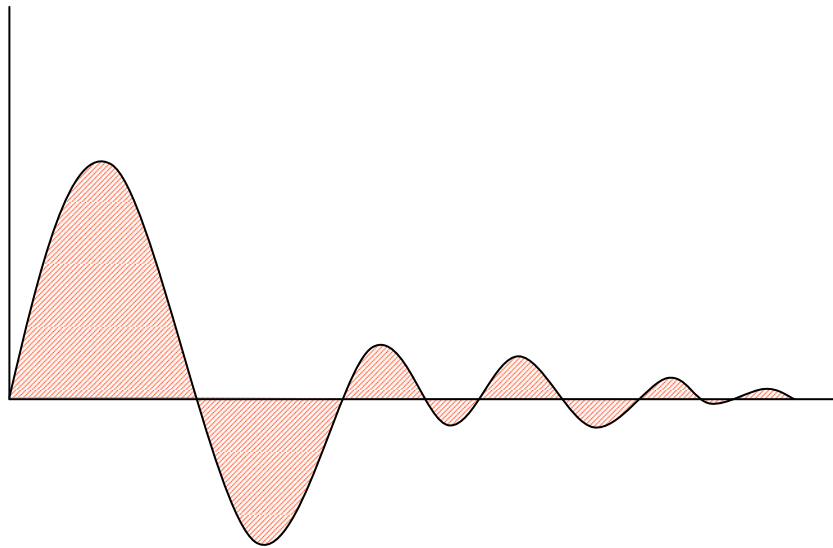


## 04 Background – Sound Pressure

- Sound pressure waves are measured in Pascals (Pa)
- Often presented in decibels
- Sound Pressure Level (dB) =  $20 \log (P/P_{\text{ref}})$
- $P_{\text{ref}}$  in air is 20  $\mu\text{Pa}$
- $P_{\text{ref}}$  in water is 1  $\mu\text{Pa}$

## 05 Background - Impulse

- Impulse is the area under the pressure time curve
- Measured in Pa.s



## 06 Background - Physiology

- The lung is the most sensitive organ to blast
  - Air filled
  - Acoustic impedance of lungs vastly different to body tissue and water
- Water borne blast waves will travel
  - From water to body tissue with little change, but will
  - reflect at the lung
  - Resulting in lung trauma

## 07 Review of Underwater Blast Limits

- Sources
  - Bebb and Wright, Christian and Gaspin, USN diving manual (1970), Yelverton, Rawlings, Cameron, Parvin, Cudahy, plus others
- Limits need to be conservative
  - Pilot and co-pilot gunner need to orientate themselves quickly to escape
- Many of the studies were performed at a distance (far field)
  - Little short range data (near field)
    - Noise from diver operated tools
    - Documented accidents with explosives
- Christian and Gaspin proposed safe limits 345 kPa and 14 Pa.s
  - Animal studies showed no physical damage at 862 kPa and 39 Pa.s

## 08 Review of Underwater Blast Limits - Proposed limits

	Peak pressure	Impulse
Maximum allowable	345 kPa 230 dB re 1 $\mu$ Pa	100 Pa.s
Goal for Apache CJS	100 kPa 220 dB re 1 $\mu$ Pa	14 Pa.s

## 09 Testing of the AH CJS

- Simple immersion tests of the CJS
  - Performed as function test rather than acoustic
  - CJS Handle with MDC
  - Showed the system functioned after a long immersion
  - Peak pressure levels were potentially very high
- Phased Testing of AH CJS
  - Box tests
  - Full scale mock-up
  - Testing US AH-64A Canopy

# 10 Testing of the AH CJS

- Box tests
  - Developed to enable repeatable low cost tests to be performed
  - Performed in the Experimental Diving Tank (3 x 3 x3 m) at QinetiQ Alverstoke, UK
- Three conditions
  - Air filled in air
  - Air filled submerged in water
  - Water filled submerged in water
- Hydrophone
  - Placed inside box
  - Result 33000 kPa (270 dB re 1  $\mu$ Pa)
  - Limit 345 kPa (230 dB re 1  $\mu$ Pa)



# 11 Testing of the AH CJS

- Full scale mock-up
  - Replica of AH MK1 canopy
  - Mannequins dressed in representative AH AEA
- Hydrophones placed on
  - Chest
  - Inside helmet
  - 5 m
  - 20 m
- Performed in Ocean Basin facility at QinetiQ Haslar
  - 120 m long
  - 60 m wide
  - 5.5 m deep



## 12 Testing of the AH CJS

- Mannequin dressed in representative AH AEA (Aircrew Equipment & Assemblies)
- Results
  - Pressure levels reached 17000 kPa
    - (265 dB re 1  $\mu$ Pa)
  - Limit 345 kPa
    - (230 dB re 1  $\mu$ Pa)



## 13 Testing of the AH CJS

- To check the results from full scale mock up
  - Borrowed a US AH 64A canopy
  - Performed same tests



# 15 Testing of the AH CJS

- Results
  - Pressure levels reached 18000 kPa
    - (265 dB re 1  $\mu$ Pa)
  - Limit 345 kPa
    - (230 dB re 1  $\mu$ Pa)



## 16 Testing of the AH CJS

Example of fractured canopy



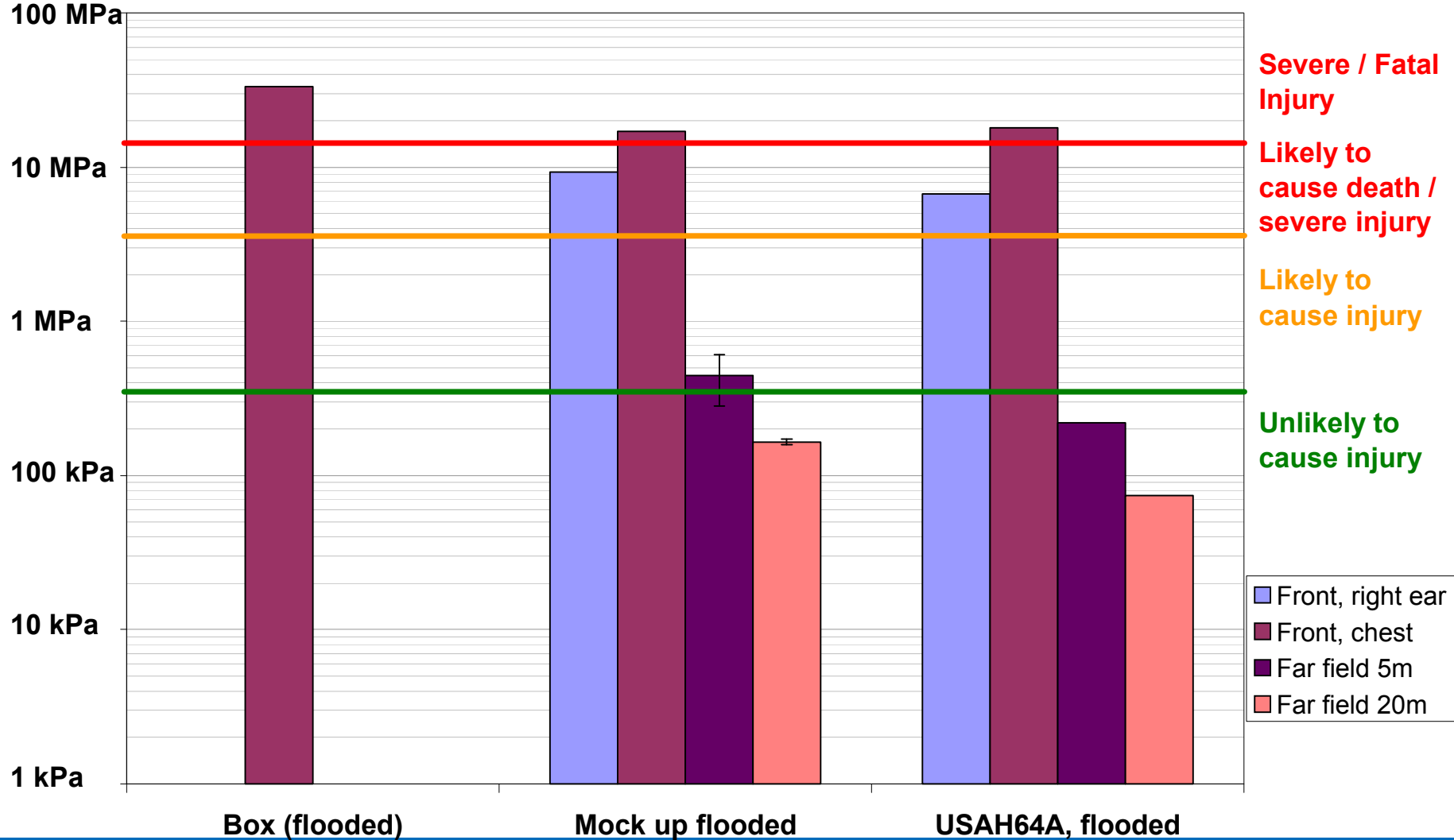
## 17 Testing of the AH CJS



## 18 Testing of the AH CJS



# 19 Comparison of results



## 20 Conclusions

- Three different methods produced similar noise levels
  - Box
  - Full scale mock up of Apache
  - Real US AH64A
- Box and full scale mock up have been validated for testing improved CJS
  - No need to acquire another Apache canopy
- Literature Review identified limits
  - maximum pressure 345 kPa, goal 100 kPa
  - maximum impulse 100 Pa.s, goal 14 Pa.s
- The in-service CJS exceeded maximum pressure and impulse limits



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