Heavy Torpedo warhead IM tests assessment

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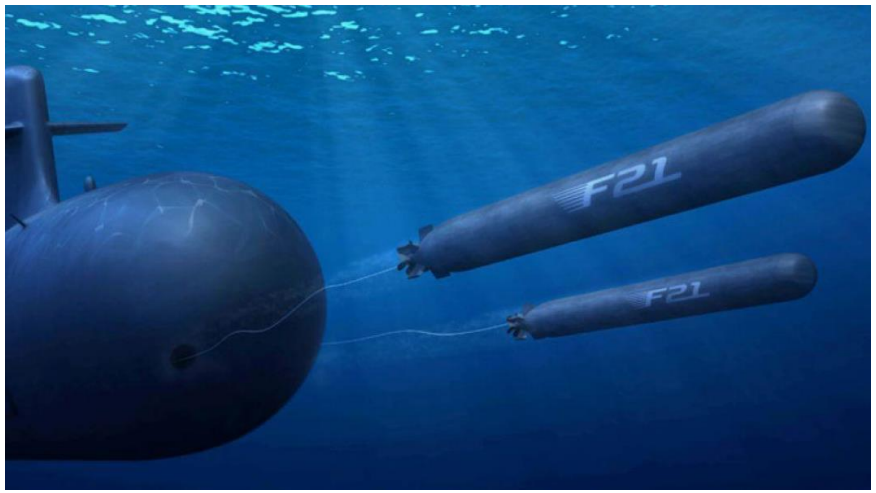
OUTLINE

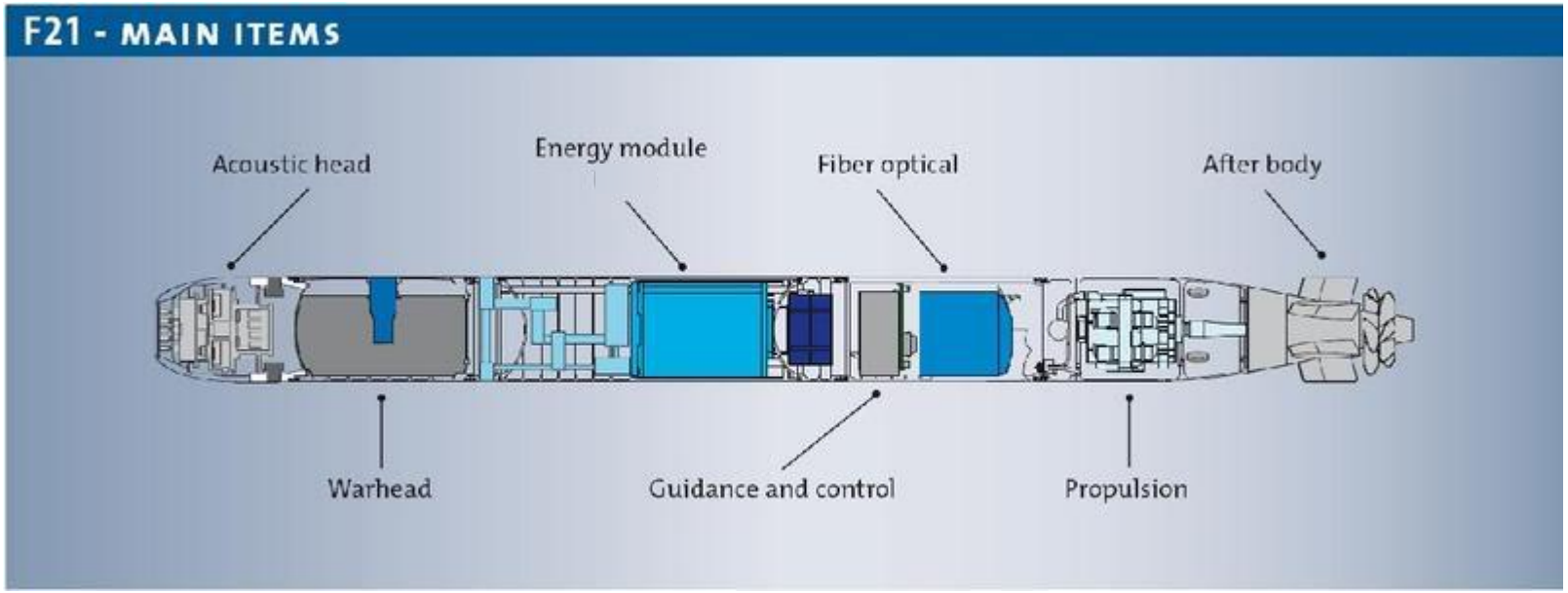
- **Presentation of the F21 heavyweight Torpedo**
- **Presentation of F21 Heavy Torpedo warhead design**
- **Fast Cook-Off and Shaped charge Jet Tests**
- **IM signature**

F21 Heavyweight Torpedo

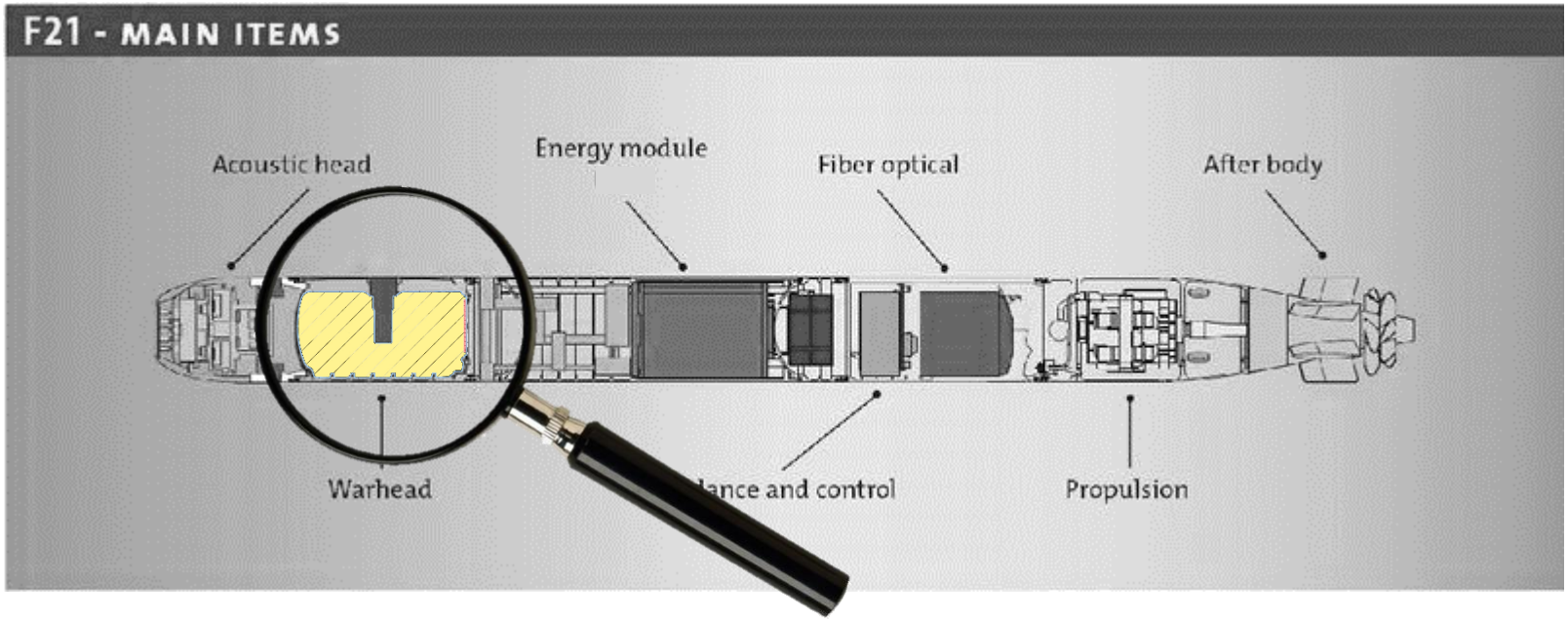


Characteristics	Value
Length	6 m
Weight	1 500 kg
Diameter	533,4 mm
Range	> 50 km
Speed	> 50 knots
Propulsion	Electric
Guidance	Automatic or optical fiber

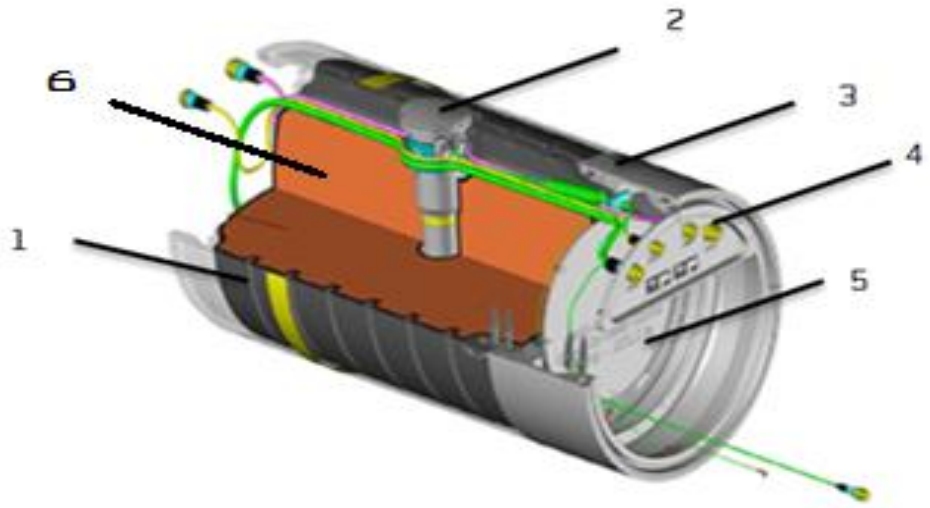
F21 Heavyweight Torpedo



F21 Heavyweight Torpedo



Warhead



Item	Description
1	Aluminum body
2	Impact Fuze
3 & 4	Cables & Connectors
5	Closing plate
6	Main charge Explosive + thermal protection + thermal fuze

Warhead

Main charge explosive

Characteristics	Value
Main charge Explosive Technology	Cast-cure PBX
Main charge Explosive	B2211D
Main charge Explosive components	I-RDX®/ AP / Al / IB HTPB-Based
Warhead Diameter	533,4 mm
Net Explosive Weight	250 kg
Warhead Gross Weight	348 kg

- **Fully qualified to STANAG 4170**
- **Underwater applications : mines, torpedo warheads,**
- **Anti-ship missile warheads**

Warhead

Main charge explosive : B2211D

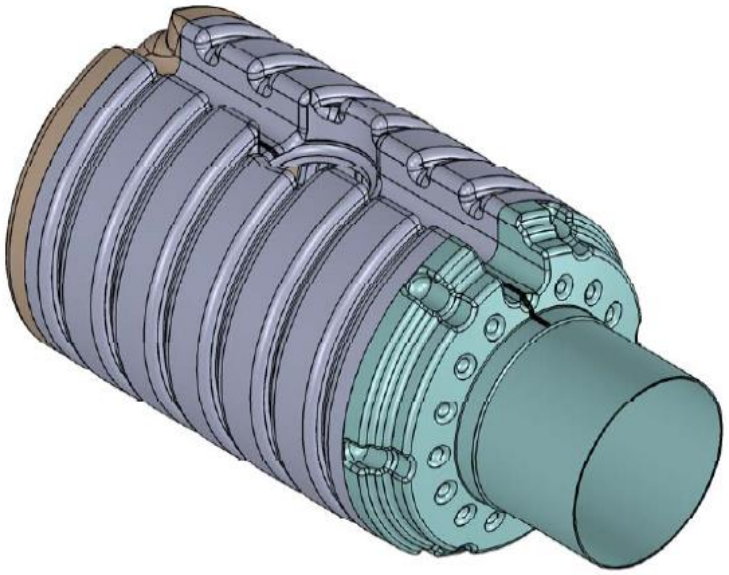
Performance characteristics	Value
TNT Factor (Peak / Energy / Bubble effect)	1,4 / 1,4 / 2,1
Density	1,810
Detonation velocity	5 500 $m.s^{-1}$

Safety characteristics	Value
Auto-ignition Temperature - STANAG 4491 (°C)	200 °C
Critical diameter	76 mm
Friction sensitivity - STANAG 4489	33 J
Impact Sensitivity - STANAG 4487	70 N
Card Gap Test Ø40mm - STANAG 4488	80 cards
Capacity discharge - STANAG 4490	No reaction

EIDS - Extremely Insensitive Detonating Substance

Warhead

Thermal Protection



- **Rubber based technology**
- **Reinforced rubber material against thermal threats**
- **Composed of 5 sub-components**
- **Prevent mechanical friction of Main charge explosive with the metallic body**
- **Inserted into the empty warhead before filling**

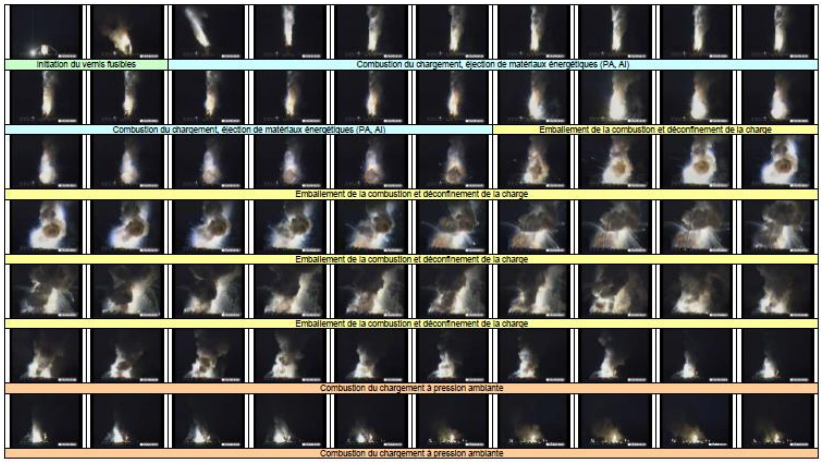
Warhead

Thermal Fuze varnish

- **HTPB-based live compound**
- **Density : 1,058**
- **Self-ignition temperature under slow-heating stimuli : approx. 165 °C**
- **Feature : locally initiate the main charge explosive when temperature reaches 165°C and prevent core-initiation of the main charge and related violent reactions**

Warhead

Thermal Fuze varnish : Slow Cook-Off test

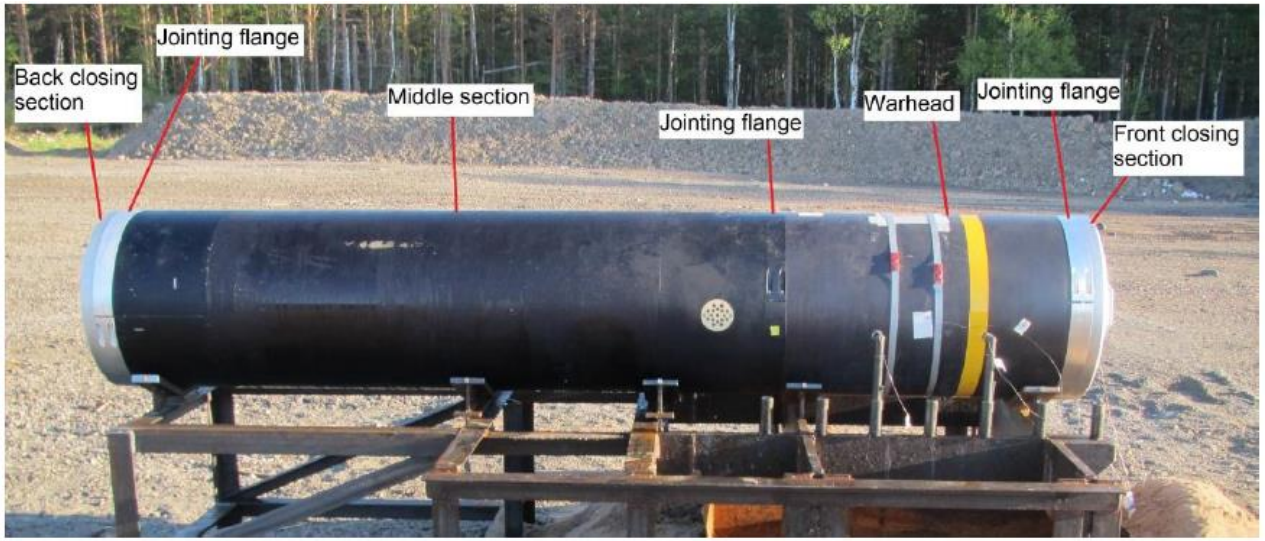


- **Application : Slow Cook-Off threat**
- **165 °C : initiation of thermal fuze located in the back end of the main charge**
- **Start of burning of main charge explosive**
- **Linear combustion of the main charge**
- **Fast burning and low level of reaction**

IM Assessment

Fast Cook-Off Test

- **Test setup : IAW STANAG 4240**
- **Fuel fire stimuli**
- **Specimen configuration : Warhead section + battery section**



IM Assessment

Fast Cook-Off Test

- **T0 : burning of fuel**
- **T0 + 17' : burning of the main charge explosive**
- **T0 + 45' : complete warhead has burnt**

Level of Reaction IAW STANAG 4439 : Type V (Burning)

IM Assessment

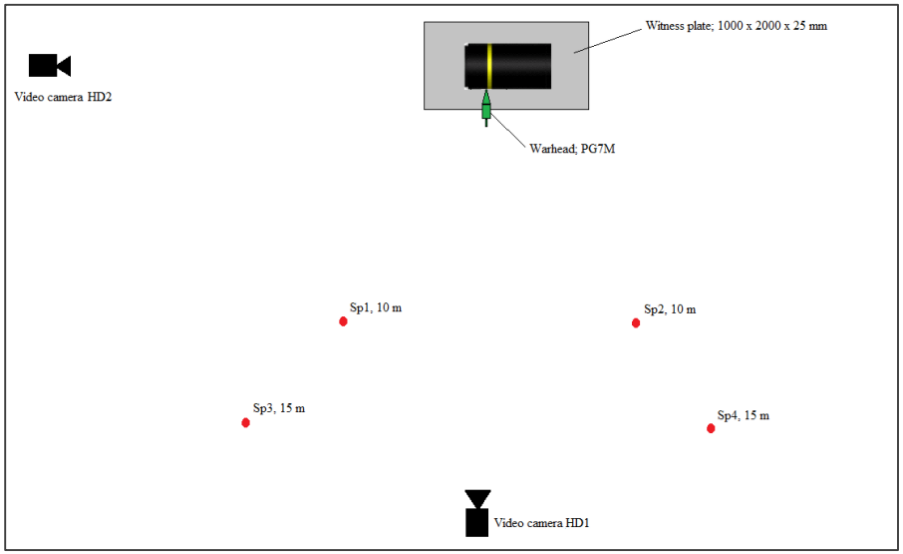
Shaped Charge Test

- **Test setup : IAW STANAG 4526**
- **Shaped charge warhead : RPG-7 (PG7M)**
  - Caliber : 70 mm
  - Steel armor penetration : 300 mm
  - Main charge explosive : A IX-1 (96% RDX, 4% wax)
  - Net Explosive Weight : 320 g

IM Assessment

Shaped Charge Test

- **Test setup : IAW STANAG 4526**
- **Instrumentation**
  - Measurement Pressure gauges
  - Steel witness plate
  - High Speed camera



IM Assessment

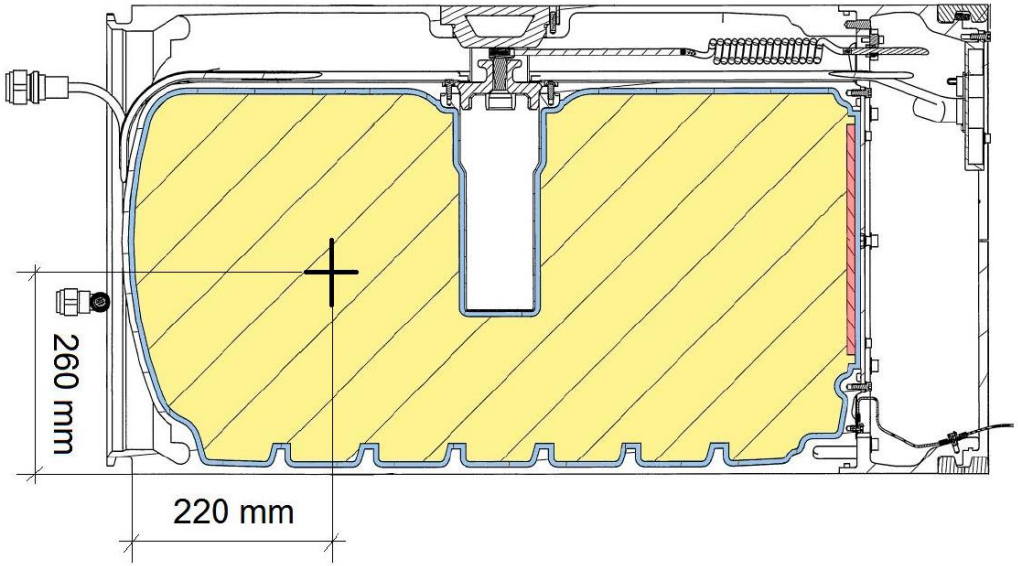
Shaped Charge Test

- **Test setup : IAW STANAG 4526**
- **Test configuration : SC in contact with the warhead (no mitigation device)**

IM Assessment

Shaped Charge Test

- **Test setup : IAW STANAG 4526**
- **Test configuration : aim-point calculated to maximize the cross section of live material to be hit by the shaped charge jet**



IM Assessment

Shaped Charge Test

- **T0 : initiation of the Shaped charge.**
- **Front end of the warhead is cut from the body : massive fragment projected**

IM Assessment

Shaped Charge Test

- **T0 + 3” : start of burning of the main charge explosive.**
- **T0 + 8’ : end of burning of the main charge explosive**

IM Assessment

Shaped Charge Test

- **Maximum Air blast pressure measured**

Registered maximum air blast pressure values (kPa)			
Sp1, 10 m	**Sp2, 10 m**	**Sp3, 15 m**	**Sp4, 15 m**
10.1	10.7	6.0	6.4

- **Most part of air blast pressure probably due to the shaped charge itself, but no reference test performed**

IM Assessment

Shaped Charge Test

- **Close-up view after the test. No impact/damage on witness plate.**

IM Assessment

Shaped Charge Test

- **Five pieces of unreacted high explosive recovered**

IM Assessment

Shaped Charge Test

- **Fragment distribution (not to scale)**

No.	Description	Weight (g)	Projection distance (m)
1	Rear part of the warhead.	46 500	1.15
2	Fragment from the warhead.	1 335	1.62
3	Unreacted high explosives.	164	18.96
4	Unreacted high explosives.	193	9.82
5	Fragment from the warhead.	1 655	8.30
6	Fragment from the warhead.	4 000	10.57
7	Unreacted high explosives.	253	16.82
8	Fragment from the warhead.	214	36.61
9	Unreacted high explosives.	120	5.47
10	Front part of the warhead.	14 500	34.06
11	Unreacted high explosives.	431	13,58
12	Unreacted high explosives.	558	22.04
13	Fragment from the warhead.	50	24.31

IM Assessment

Shaped Charge Test

- **Unreacted high explosive recovered : 1,7 kg**
- **Total weight of inert material recovered : 68,2 kg**
- **Massive fragment (front end) 14,5 kg recovered at 34 m from witness plate**
- **Low level of air blast measured**

Level of Reaction IAW STANAG 4439 : Type IV (Deflagration)

IM Signature

- **IM Signature of F21 heavyweight torpedo warhead performed IAW STANAG 4439 / AOP-39**

STANAG 4439 Requirements		FH	SH	BI	SR	FI-L	FI-H	SCJI
IM Signature	NR							
	V	●		○		○		
	IV		●					●
	III				○		○	
	II							
	I							

Full compliance with STANAG 4439

● : Assessment by Full-scale trial

○ : Assessment by analysis and/or read-across with other configurations

Acknowledgements

DGA

SAAB BOFORS TEST CENTER AB

ARIANE GROUP

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