

出國報告(出國類別:其他)

4000 噸級巡防艦主機廠試 出國報告

服務機關：海洋委員會海巡署艦隊分署

姓名職稱：主任秘書 陳泰廷

科 長 曾俊瑜

技 正 柯翔樟

派赴國家/地區：德國

出國期間：108 年 7 月 23 日起至 8 月 4 日止

報告日期：108 年 9 月 25 日

摘要

本次為海洋委員會海巡署艦隊分署 4000 噸級巡防艦 4 艘統包採購案 (契約案號：B107240) 首艘艦主機工廠測試 (Factory Acceptance Tests , FAT)，於德國 MTU 主機工廠(福吉沙芬 Friedrichshafen) 進行。

為確保案內巡防艦主機於裝船前性能數據均符合契約規定，且因本型主機型號為艦隊分署史上最大馬力(單部主機達 9100kw)，爰慎重其事，規劃由主任秘書陳泰廷、建造技術科科長曾俊瑜及技正柯翔幃等 3 員，會同中國驗船中心、台灣國際造船股份有限公司(本統包案承商)及財團法人船舶暨海洋產業研發中心(本案專案管理公司)人員共同參與本次廠試，依採購契約等規定驗證本艦主機是否符合廠試規範。

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1. 目的

本分署「4000 噸級巡防艦 4 艘統包採購案」於 107 年 7 月 18 日由台灣國際造船股份有限公司得標承作，其負責「籌建海巡艦艇發展計畫」4000 噸級巡防艦之設計及建造工作，為確認案內新造巡防艦配備之主機可滿足未來任務需求，依採購契約規定，所採購之主機應依契約要求及船級協會標準實施廠試。

本案主機廠試試驗於德國福吉沙芬(Friedrichshafen)MTU 1 廠進行測試。為善盡履約管理責任，爰由艦隊分署主任秘書陳泰廷、建造技術科科長曾俊瑜及技正柯翔樟陪同中國驗船中心高雄聯絡處處長高世榮(資深驗船師)、台灣國際造船股份有限公司設計處副理丁案群及財團法人船舶暨海洋產業研發中心工程師劉昱辰、張旭如等人，共同參加本次主機廠試試驗，見證本次試驗內容及施作程序確實符合契約規範。

2. 行程表

日期	起始地點	工作摘要說明
108年7月23日	台北(桃園)-泰國(曼谷)轉機	搭乘泰國航空
108年7月24日	飛機：泰國(曼谷)-瑞士(蘇黎世) 地面運輸：瑞士(蘇黎世)-德國(福吉沙芬)	由瑞士蘇黎世搭乘火車及渡輪，前往福吉沙芬
108年7月25日	福吉沙芬	實施 MTU 主機廠試前總說明簡報暨安全提示
108年7月26日	福吉沙芬	實施首部主機廠試作業
108年7月27日	福吉沙芬	首部主機廠試作業後文件資料研析
108年7月28日	福吉沙芬	第二部主機測試前情況預擬及因應研討
108年7月29日	福吉沙芬	參訪 MTU 教育訓練中心
108年7月30日	福吉沙芬	參訪 MTU 廠區及 MTU 混和動力發展介紹
108年7月31日	福吉沙芬	首部主機運抵 MTU 2 廠預備塗裝及打 CR 鋼印
108年8月1日	福吉沙芬	實施第二部主機測試前預備會議暨再次確認安全提示
108年8月2日	福吉沙芬 自行駕車：福吉沙芬-慕尼黑	實施第二部主機廠試作業
108年8月3日	飛機：慕尼黑-泰國(曼谷)轉機	搭乘泰國航空
108年8月4日	德國(慕尼黑)-泰國(曼谷)轉機-台北(桃園)	搭乘泰國航空

3. MTU 主機廠試過程

3.1 確認廠試流程

本分署與台灣國際造船股份有限公司、財團法人船舶暨海洋產業研發中心、中國驗船中心人員於 108 年 7 月 25 日前往位於德國福吉沙芬 (Friedrichshafen) 的 MTU 工廠 (Plant 1)，於主機正式廠試前確認流程，由 MTU 廠方代表 **Marine and Defense Business 副總裁 (Vice President) Knut Muller** 親自接見，並由主任秘書陳泰廷代表艦隊分署致贈其紀念品，以及 Product Approval and Acceptance 資深經理 (Senior Manager) Philipp Gleissner、工程主管專員 (Master of Engineering) Anna-Lisa Schonegg 等人講解廠區測試台相關安全守則及逃生路線宣導，俾使主機廠試順利完成。

3.2 主機基本資料

下表為本案主機廠家資料：

數量	每艦 2 部
最大輸出馬力 (kW)	9,100 kw (符合規範 9,100 kw 要求)
汽缸數	20 汽缸
額定轉速	1,150 RPM (每分鐘 1,150 轉)

3.3 測試項目

- (1) 測試前準備
- (2) 主機外觀檢查
- (3) 最低轉速測試
- (4) 負載運轉測試
 - A. 無負載 (0kw)，380rpm 測試 10 分鐘
 - B. 4.4%負載 (405kw)，380rpm 測試 30 分鐘
 - C. 25%負載 (2,275kw)，724rpm 測試 30 分鐘

- D. 50%負載(4,550kw) , 913rpm 測試 30 分鐘
- E. 75%負載(6,825kw) , 1,045rpm 測試 30 分鐘
- F. 85%負載(7,735kw) , 1,085rpm 測試 1 小時
- G. 90%負載(8,190kw) , 1,110rpm 測試 30 分鐘
- H. 100%負載(9,100kw) , 1,150rpm 測試 2 小時
- I. 110%負載(10,010kw) , 1,150rpm 測試 30 分鐘
- J. 測試期間觀測並記錄下列數據：
 - I. 主機負載
 - II. 主機轉速
 - III. 溫度及壓力等儀表數據
- (5) 燃油耗油量計測
- (6) 自動馬力負荷限制測試
- (7) 調速器測試
- (8) 啟動測試(標準啟動 6 次)
- (9) 安全保護裝置測試
- (10) 噪音強度測試
- (11) 拆放檢驗(拆卸滑油過濾器檢驗)

3.4 主機廠試小結

本次依計畫期程於 108 年 7 月 25 日至 8 月 2 日實施 4000 噸巡防艦首艦主機廠試，每部主機測試作業均依測試計畫及程序逐一施作，並於完成廠試項目後，隨即召開廠試後會議，經檢視相關測試報告，均符合規範要求。

因受限於測試模台高度限制，本次廠試時未安裝進氣消音器，然於全負載運轉時噪音測試分析為 108.5 分貝，已低於規範要求之 110 分貝，未來安裝於艦上時將再加裝進氣消音器，於噪音抑制上將更優於規範要求。

本次廠試除於全負載(9,100kw)運轉 2 小時測試外，更以 110%負載(10,010kw)運轉達 30 分鐘測試，且於全負載運轉期間多次檢視機件

均無任何洩漏狀況(如滑油、燃油等)，全般運轉測試完成後亦拆卸滑油過濾器檢驗，並經分析所濾殘渣中不含任何金屬成分，確保主機無不當磨耗，顯見設計餘裕充足，品質優異無虞。

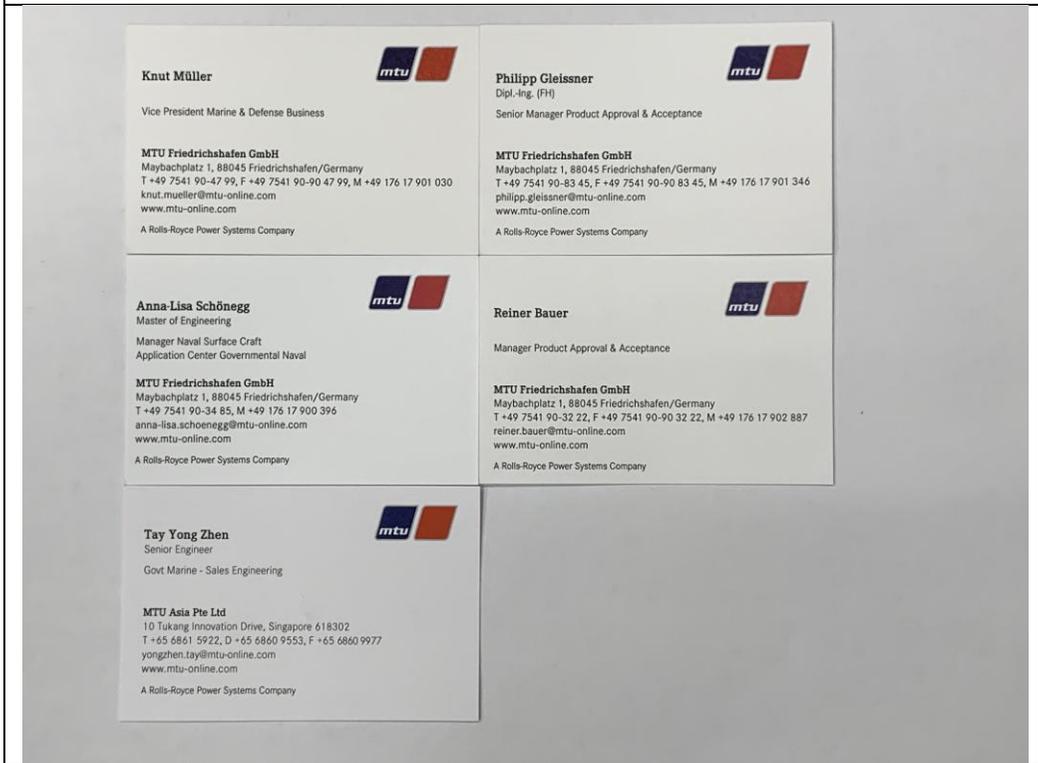
3.5 主機廠試照片集錦



主任秘書陳泰廷致贈副總裁 Knut Muller 紀念品



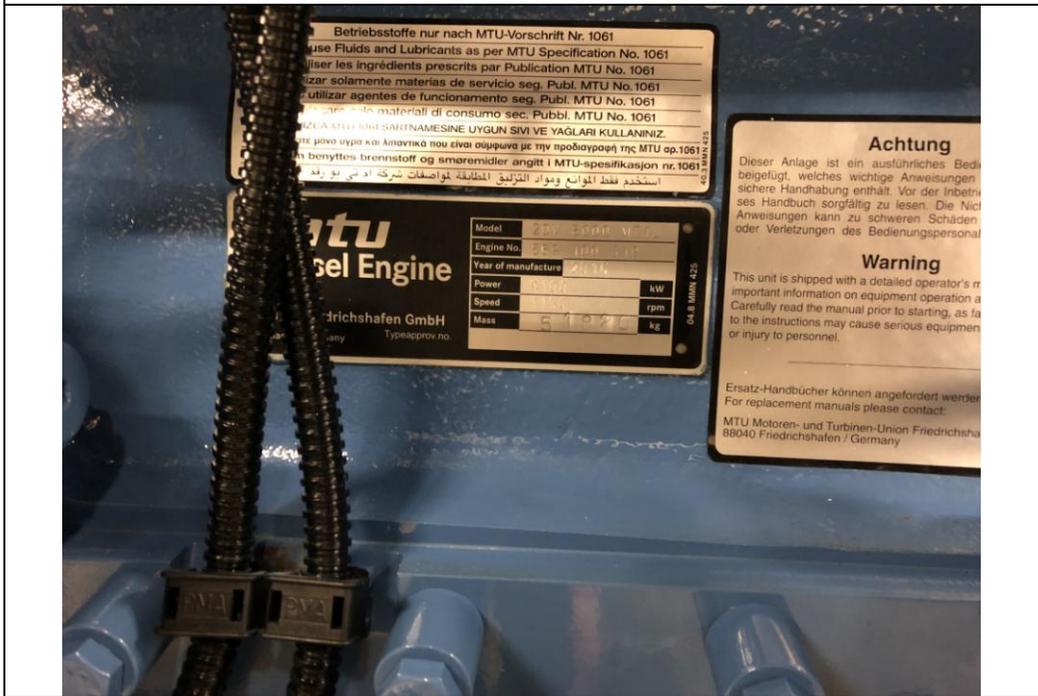
副總裁 Knut Müller 試戴艦隊分署紀念便帽



副總裁 Knut Müller 等人名片



測試前會議



核對主機序號



噪音測量



主機運轉測試



主機全負載時檢查是否有洩漏狀況



檢查滑油濾芯，以確定機件無異常磨耗情形

Power Calculation		Fuel Type	DIN EN 580	Power Definition acc.	ISO 3046	Altitude ab. Sea Level	400 m	Barometric Pressure	967 mbar	Page	1 of 3															
P _{y=2m} = 2M ₍₂₅₎ / 1000		Spec. Density at 15°C	0.82-0.84 g/cm ³	Continuous Power	Overload Power	Intake Air Temperature	25 degC	Direction of Rotation ISO 1204	ccw (counter-clockwise)	Date	02.08.2019															
		Calorific Value	>42900 kJ/kg	Overload Power	9100 kW at 1150 rpm	Relative Humidity	60%	Direction of Rotation ISO 1204	ccw (counter-clockwise)	Testbench	130															
		Lube Oil Type	MTU approved	Fuel Stop Power	9100 kW at 1150 rpm	Raw Water Temp.	25 degC	Operator		Operator	Geng, Hartl															
Time	Speed	Torque	Engine Power	Fuel	Temp.	Temp.	Temp.	Temp.	Temp.	Temp.	Temp.	Temp.														
h:min	rpm	Nm	kW	lph	g/kWh	before Engine ECS bar	after Engine ECS degC	before Pump ECS bar	before Engine ECS degC	before Cyl. ECS bar abs.	Turbo A1 ECS krpm	Turbo A2 ECS krpm	Turbo B1 ECS krpm	Turbo B2 ECS krpm	number of active Turbos	after Engine degC	Press. mbar	FSM	before Engine ECS degC	in Rail ECS bar	before Engine ECS degC	after Pump bar				
07:00																										
sec.																										
600	380	758	30	13	422.8	1.3	3.6	71	68	69	1.0	32	58	0.97	2.8	2.7	2.8	2.9	4	177	0	0.26	26	700	25	0.83
1800	380	10178	405	94	232.7	1.2	3.5	71	67	68	0.9	32	59	1.03	0	7.9	0	7.7	2	270	0	0.36	25	750	25	0.86
1800	724	30009	2275	470	206.3	5.4	6.3	72	69	71	2.5	30	55	2.20	0	27.9	0	27.7	2	349	0	0.18	25	1050	25	1.59
1800	913	47593	4550	923	202.9	7.0	7.9	72	69	72	3.7	30	51	2.84	0	31.9	31.7	31.7	3	424	14	0.30	25	1050	26	2.21
1800	1045	62372	6525	1411	206.4	6.9	7.8	71	69	73	4.8	31	45	3.24	33.9	34.0	33.8	33.8	4	504	23	0.35	27	1150	25	2.72
1800	1085	68082	7735	1564	202.0	6.8	7.7	70	69	73	5.1	32	44	3.50	35.3	35.5	35.3	35.3	4	482	26	0.27	27	1300	25	2.89
1800	1085	68082	7735	1565	202.1	6.8	7.7	70	69	73	5.1	32	44	3.50	35.5	35.5	35.3	35.3	4	482	26	0.28	27	1300	25	2.91
1800	1110	70464	8190	1668	203.5	6.8	7.7	69	69	73	5.3	33	43	3.71	35.5	36.6	36.5	36.5	4	469	27	0.28	27	1300	25	3.03
1800	1150	75570	9100	1850	204.0	6.7	7.6	67	69	73	5.7	34	41	4.04	35.1	38.4	38.3	38.4	4	457	28	0.33	27	1300	25	3.22
1800	1150	75570	9100	1877	205.8	6.7	7.6	67	74	79	5.8	45	46	3.90	38.7	39.0	38.8	38.7	4	494	32	0.49	32	1300	32	3.11
1800	1150	75570	9100	1875	205.9	6.7	7.6	67	74	79	5.8	44	46	3.89	38.7	39.0	38.7	38.7	4	464	33	0.52	32	1300	32	3.10
1800	1150	75570	9100	1875	205.8	6.7	7.6	67	74	79	5.8	44	46	3.88	38.6	39.0	38.7	38.7	4	466	33	0.47	32	1300	32	3.10
1800	1150	75570	10010	2070	206.8	6.7	7.6	69	79	84	6.0	45	48	4.20	40.2	40.2	40.5	40.5	4	510	37	0.36	32	1600	32	3.11
1100	79091	9110	Speed Limitation Curve																							
1000	69476	7275																								
900	69426	6260																								
700	55526	4070																								
500	44694	2340																								
1187	3017	375	Governortest																							
15:30	Stop		Functional test																							

Dataset No. X0065522
In case of sensor value 0 no sensor system available
Depending on intake air temperature the rated power as well as operation values can deviate from technical sales documentation (TSD).
Automatic Test Protocol / Measurements averaged / also valid without signature

No faults or deficiencies occurred during the acceptance test.
For MTU Friedrichshafen GmbH

Instruction: XZ599003-324357 V9.0
Performance Diagram: XZ5990000073
Alarm and Limit Value List: XZ599010-204675
Lube oil filter check: O.K.

廠試紀錄 - 1

Power Calculation		Fuel Type	DIN EN 580	Power Definition acc.	ISO 3046	Altitude ab. Sea Level	400 m	Barometric Pressure	967 mbar	Page	1 of 3																		
P _{y=2m} = 2M ₍₂₅₎ / 1000		Spec. Density at 15°C	0.82-0.84 g/cm ³	Continuous Power	Overload Power	Intake Air Temperature	25 degC	Direction of Rotation ISO 1204	ccw (counter-clockwise)	Date	02.08.2019																		
		Calorific Value	>42900 kJ/kg	Overload Power	9100 kW at 1150 rpm	Relative Humidity	60%	Direction of Rotation ISO 1204	ccw (counter-clockwise)	Testbench	130																		
		Lube Oil Type	MTU approved	Fuel Stop Power	9100 kW at 1150 rpm	Raw Water Temp.	25 degC	Operator		Operator	Geng, Hartl																		
Time	Speed	Torque	Engine Power	Single Exhaust Temperature													Combined Exhaust												
h:min	rpm	Nm	kW	A1 EMU degC	A2 EMU degC	A3 EMU degC	A4 EMU degC	A5 EMU degC	A6 EMU degC	A7 EMU degC	A8 EMU degC	A9 EMU degC	A10 EMU degC	B1 EMU degC	B2 EMU degC	B3 EMU degC	B4 EMU degC	B5 EMU degC	B6 EMU degC	B7 EMU degC	B8 EMU degC	B9 EMU degC	B10 EMU degC	ETC 1 degC	ETC 2 degC	ETC 3 degC	ETC 4 degC		
07:00																													
sec.																													
600	380	758	30	124	126	123	123	124	118	117	114	110	226	212	226	217	207	216	215	216	216	220	218	n/a	n/a	n/a	n/a	n/a	n/a
1800	380	10178	405	296	281	297	304	301	303	288	269	284	313	291	274	291	278	271	279	279	282	289	286	n/a	n/a	n/a	n/a	n/a	n/a
1800	724	30009	2275	441	431	450	457	463	457	467	438	434	455	441	423	439	444	429	431	442	438	431	421	n/a	n/a	n/a	n/a	n/a	n/a
1800	913	47593	4550	541	537	548	550	539	547	527	542	554	524	531	529	541	551	535	534	536	545	533	513	n/a	n/a	n/a	n/a	n/a	n/a
1800	1045	62372	6525	622	635	629	641	633	628	623	639	638	622	621	619	633	634	635	624	631	631	610	603	n/a	n/a	n/a	n/a	n/a	n/a
1800	1085	68082	7735	616	630	621	628	625	618	619	636	630	608	611	612	619	630	627	617	616	617	599	586	n/a	n/a	n/a	n/a	n/a	n/a
1800	1085	68082	7735	617	631	621	628	626	619	619	637	630	608	612	612	620	631	628	616	616	618	600	586	n/a	n/a	n/a	n/a	n/a	n/a
1800	1110	70464	8190	615	629	621	627	629	621	621	644	633	611	613	612	618	629	626	613	615	618	589	586	n/a	n/a	n/a	n/a	n/a	n/a
1800	1150	75570	9100	618	629	621	629	635	621	623	635	630	603	618	624	624	637	646	625	625	609	610	590	n/a	n/a	n/a	n/a	n/a	n/a
1800	1150	75570	9100	658	670	661	666	674	661	662	674	668	644	657	662	663	675	682	663	663	663	645	627	n/a	n/a	n/a	n/a	n/a	n/a
1800	1150	75570	9100	659	670	661	667	675	661	662	674	668	646	656	662	663	675	682	663	663	663	645	626	n/a	n/a	n/a	n/a	n/a	n/a
1800	1150	75570	9100	659	671	662	667	675	661	661	674	667	645	656	664	664	675	684	664	664	664	646	630	n/a	n/a	n/a	n/a	n/a	n/a
1800	1150	83127	10010	688	698	691	697	699	686	689	705	697	675	686	691	691	701	705	688	689	699	675	659	n/a	n/a	n/a	n/a	n/a	n/a

Dataset No. X0065522
In case of sensor value 0 no sensor system available
Depending on intake air temperature the rated power as well as operation values can deviate from technical sales documentation (TSD).
Automatic Test Protocol / Measurements averaged / also valid without signature

No faults or deficiencies occurred during the acceptance test.
For MTU Friedrichshafen GmbH

Instruction: XZ599003-324357 V9.0
Performance Diagram: XZ5990000073
Alarm and Limit Value List: XZ599010-204675
Lube oil filter check: O.K.

廠試紀錄 - 2

Inspection Report															Model No. 20V8000M71L																																										
MTU Engine															Serial No. 569100319																																										
															Order No. 1204675																																										
Power Calculation $P_{75} = 2 \pi M(\frac{N}{60}) / 1000$		Fuel Type Spec Density at 15°C Calorific Value Lube Oil Type		DIN EN 590 0.82-0.84 g/cm ³ >42900 kJ/kg MTU approved		Power Definition acc. ISO 3046 Continuous Power Overload Power Fuel Stop Power		9100 kW at 1150 rpm		Altitude ab. Sea Level Intake Air Temperature Relative Humidity Raw Water Temp.		400 m 25 gr/c 60% 25 gr/c		Barometric Pressure Direction of Rotation ISO 1204 cw (clockwise)		964 mbar		Page Date Testbench Operator		2 of 3 26.07.2019 130 Vadic, Geng																																					
Time		Speed		Torque		Engine Power		Single Exhaust										Combined Exhaust																																							
h:min		rpm		Nm		kW		A1 A2 A3 A4 A5 A6 A7 A8 A9 A10 B1 B2 B3 B4 B5 B6 B7 B8 B9 B10										ETC 1 ETC 2 ETC 3 ETC 4																																							
07:15						Start Acceptance of engine power																																																			
sec.																																																									
900		380		628		25		165		160		162		167		169		171		167		170		173		102		103		103		104		103		101		105		101		100		101		n/a		n/a		n/a		n/a					
1800		380		10178		405		295		287		281		295		301		289		296		297		295		311		291		282		288		276		287		296		280		306		286		292		n/a		n/a		n/a		n/a			
1800		724		30009		2275		448		446		442		451		451		445		457		456		472		454		449		450		454		442		446		458		449		458		477		442		n/a		n/a		n/a		n/a			
1800		913		47593		4550		565		556		559		566		566		558		593		582		586		556		538		542		550		545		551		536		553		539		540		510		n/a		n/a		n/a		n/a			
1800		1045		52372		6825		628		630		639		638		627		632		644		651		647		589		628		637		644		650		648		632		653		641		645		611		n/a		n/a		n/a		n/a			
1800		1085		68062		7735		621		618		628		633		621		627		632		640		635		590		623		627		634		636		633		623		645		636		637		604		n/a		n/a		n/a		n/a			
1800		1085		68062		7735		623		618		627		632		621		626		632		641		635		590		624		629		635		638		634		624		645		636		638		604		n/a		n/a		n/a		n/a			
1800		1110		70454		8190		619		616		628		631		619		628		633		636		632		588		626		630		637		636		633		626		647		636		638		605		n/a		n/a		n/a		n/a			
1800		1150		75570		9100		625		624		636		638		626		633		643		645		643		596		631		637		641		645		637		633		650		640		647		609		n/a		n/a		n/a		n/a			
1800		1150		75570		9100		642		643		654		657		644		652		662		664		661		614		649		656		659		663		654		651		669		658		665		627		n/a									
1800		1150		75570		9100		646		645		657		659		648		654		665		669		664		616		653		658		664		669		658		654		677		666		672		634		n/a		n/a		n/a		n/a			
1800		1150		83127		10010		674		675		688		690		674		682		690		695		691		643		680		685		692		697		687		687		704		694		700		683		n/a		n/a		n/a		n/a			

Dataset No. X00056522
In case of sensor value 0 no sensor system available
Depending on intake air temperature the rated power as well as operation values can deviate from technical sales documentation (TSD).

No faults or deficiencies occurred during the acceptance test.
For MTU-Energieerzeugnisse GmbH
Automatic Test Protocol / Measurements averaged / also valid without signature

Altitude: 400 m
Intake Air Temperature: 25°C
Relative Humidity: 60%
Raw Water Temp.: 25°C

Barometric Pressure: 964 mbar
Direction of Rotation ISO 1204: cw (clockwise)

Page: 2 of 3
Date: 26.07.2019
Testbench: 130
Operator: Vadic, Geng

Typical Instruction: XZ599003-324357 V6.0
Performance Diagram: XZ5990000073
Alarm and Limit Value List: XZ599010-204675
Lube oil filter check: O.K.

S.R. Chang
Y.C. Liu
CSBC: 172 Zeng

CS Classification Society Ltd.

廠試紀錄 - 5

Inspection Report															Model No. 20V8000M71L																																
MTU Engine															Serial No. 569100319																																
															Order No. 1204675																																
Power Calculation $P_{75} = 2 \pi M(\frac{N}{60}) / 1000$		Fuel Type Spec Density at 15°C Calorific Value Lube Oil Type		DIN EN 590 0.82-0.84 g/cm ³ >42900 kJ/kg MTU approved		Power Definition acc. ISO 3046 Continuous Power Overload Power Fuel Stop Power		9100 kW at 1150 rpm		Altitude ab. Sea Level Intake Air Temperature Relative Humidity Raw Water Temp.		400 m 25°C 60% 25°C		Barometric Pressure Direction of Rotation ISO 1204 cw (clockwise)		964 mbar		Page Date Testbench Operator		3 of 3 26.07.2019 130 Vadic, Geng																											
Functional Test																																															
Test		Testspeed		Limit Value acc. Alarm and Limit value list		Action		Unit		O.K.																																					
Number of starting procedures with pneumatic		300																																													
Test overpassed		827		1323		security shut down		rpm		O.K.																																					
Crankcase pressure ECS limit 1		380		27		warning only		mbar		O.K.																																					
Crankcase pressure ECS limit 2		380		37		security shut down		mbar		O.K.																																					
Lube oil pressure limit 1		800		4.0		warning only		bar		O.K.																																					
Lube oil pressure limit 2		800		3.5		security shut down		bar		O.K.																																					
Lube oil pressure piston cooling limit 1		800		3.5		warning only		bar		O.K.																																					
Lube oil pressure piston cooling limit 2		800		3.0		security shut down		bar		O.K.																																					
Oil temperature limit 1		800		83		warning only		°C		O.K.																																					
Oil temperature limit 2		800		85		power reduction		°C		O.K.																																					
Coolant temperature limit 1		800		95		warning only		°C		O.K.																																					
Coolant temperature limit 2		800		97		power reduction		°C		O.K.																																					
Coolant pressure limit 1		800		1.6		warning only		bar		O.K.																																					
Coolant pressure limit 2		800		1.1		power reduction		bar		O.K.																																					
Crankshaft bearing temperature limit 1		800		115		warning only		°C		O.K.																																					
Crankshaft bearing temperature limit 2		800		120		security shut down		°C		O.K.																																					
Splash oil temperature limit 1		800		78		warning only		°C		O.K.																																					
Splash oil temperature limit 2		800		81		security shut down		°C		O.K.																																					
Lube oil differential pressure limit 1		800		0.6		warning only		bar		O.K.																																					
Exhaust temperature limit 1		800		100		warning only		°C		O.K.																																					
Exhaust temperature limit 2		800		110		power reduction		°C		O.K.																																					
Leak-off fuel limit						warning only				O.K.																																					
Starting air pressure consumption		Start		1		2		3		4		5		6		bar																															
		37		33		31		29		27		25		23		bar																															

Dataset No. X00056522
In case of sensor value 0 no sensor system available
Depending on intake air temperature the rated power as well as operation values can deviate from technical sales documentation (TSD).

No faults or deficiencies occurred during the acceptance test.
For MTU-Energieerzeugnisse GmbH
Automatic Test Protocol / Measurements averaged / also valid without signature

Altitude: 400 m
Intake Air Temperature: 25°C
Relative Humidity: 60%
Raw Water Temp.: 25°C

Barometric Pressure: 964 mbar
Direction of Rotation ISO 1204: cw (clockwise)

Page: 3 of 3
Date: 26.07.2019
Testbench: 130
Operator: Vadic, Geng

Typical Instruction: XZ599003-324357 V6.0
Performance Diagram: XZ5990000073
Alarm and Limit Value List: XZ599010-204675
Lube oil filter check: O.K.

S.R. Chang
Y.C. Liu
CSBC: 172 Zeng

CS Classification Society Ltd.

廠試紀錄 - 6



Measurement Report

TCE 243-19

20V 8000 M71L
Order No.: 120 4675 – Taiwan Coast Guard OPV
Acceptance Test - Airborne Noise Measurements

Date: July 29th, 2019 go Text pages: 2 Illustrations: 12

1 SUMMARY

Engine surface noise measurements according to ISO 6798 have been carried out for the first engine 20V 8000 M71L of order no. 120 4675 with engine number 569 100 319. Measurements took place on July 25th 2019 at MTU test cell 130; the engine has been tested at full load condition which is 9100 kW @ 1150 rpm. In the following report, the results of the Factory Acceptance Test (FAT) are presented.

Airborne noise measurements were carried out in accordance with ISO Standard 6798. For engines with dimensions such as those of the 20V 8000M71L this standard defines a total of 13 measuring points arranged in a measuring parallelepiped at a distance of 1 m from the engine. The measuring point positions, relative to the hypothetical rectangular parallelepiped, are depicted in fig. 1. Due to restrictions of the test cell (size, water brake, exhaust piping) measurements could not be taken at 6 positions; these positions are greyed out in fig. 1. Measurements have been taken at 13 positions, pictures of the microphones are given in fig. 2 and 3. Fig. 4 shows 13 single room level sound-pressure spectra. These spectra were logarithmically averaged in 1/3-octave bands, the resulting energy mean room level is given in fig. 5. By applying the K2-correction (room influence) given in fig. 6, the energy mean free-field level is obtained (fig. 7). This spectrum given in the 1/3-octave range from 20 Hz to 10 kHz adds up to a total A-weighted sound pressure level in 1 m distance of 108.5 dB(A).

Please note that with the actual noise test no intake air silencers have been installed as the test cell's air filters are not equipped with silencers; therefore the turbo charger noise peak at 6.3 kHz is dominating the spectrum (fig. 7). As the ship installation will be equipped with intake air silencers this peak will be reduced significantly. Fig. 8 shows that the actual measurement is similar to type approval measurements without silencers; therefore it is expected that with installed intake air silencers the result will be similar to type approval data with intake air silencers (dvg. no. 734 270e).

The overall A-weighted sound pressure level in 1 m distance to the engine is then expected to be at ca. 105 dB(A).

The acoustic behaviour of the engine is satisfactory.

Compiled by: Golbach Head of dept.: sgd. Dr. Salm

Distribution: S: EG TC
K: EGS SQC TKS TCE EGSP customer via EGSP

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T-344-0167

噪音測試報告紀錄 - 1



TCE 243-19 Page 2

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Energy mean room level of 13 measuring positions	5
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Table 2: Table of illustrations

4 MEASURING AND EVALUATION EQUIPMENT

The measuring equipment is shown in the table below:

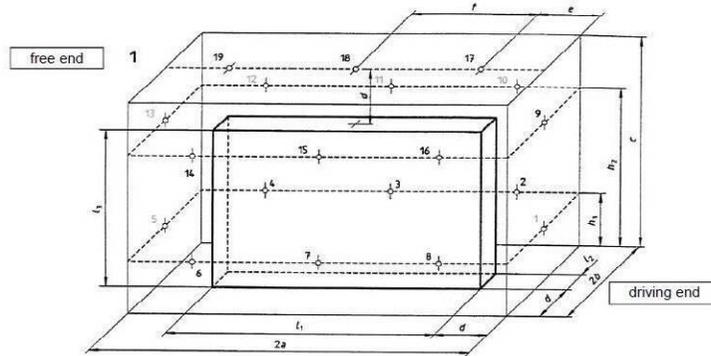
airborne noise	type	made by
microphone	HT378902	PCB
analyser	OR36/38	Oros
calibrator for airborne noise	4231 (no. 3011998)	Brüel & Kjær

Table 3: Measuring equipment

Calibration signals and calibration certificates are given in figs. 9 to 12.

噪音測試報告紀錄 - 2

Engine Noise Measurement Point Arrangement as per ISO 6798



Arrangement of 19 measurement points and measuring plane
(For engines with reference parallelepiped height > 2.5 m)

$$S = 2 \cdot 2a \cdot c + 2 \cdot 2b \cdot c + 2a \cdot 2b$$

$$l_1 = 7.2 \text{ m}; \quad l_2 = 1.8 \text{ m}; \quad l_3 = 4.3 \text{ m}; \quad h_1 = c/4; \quad h_2 = 3/4c; \quad f = 2a/3; \quad e = a/3 \quad d = 1 \text{ m}$$

$$S = 172.8 \text{ m}^2$$

$$L_S = 22.4 \text{ dB}$$



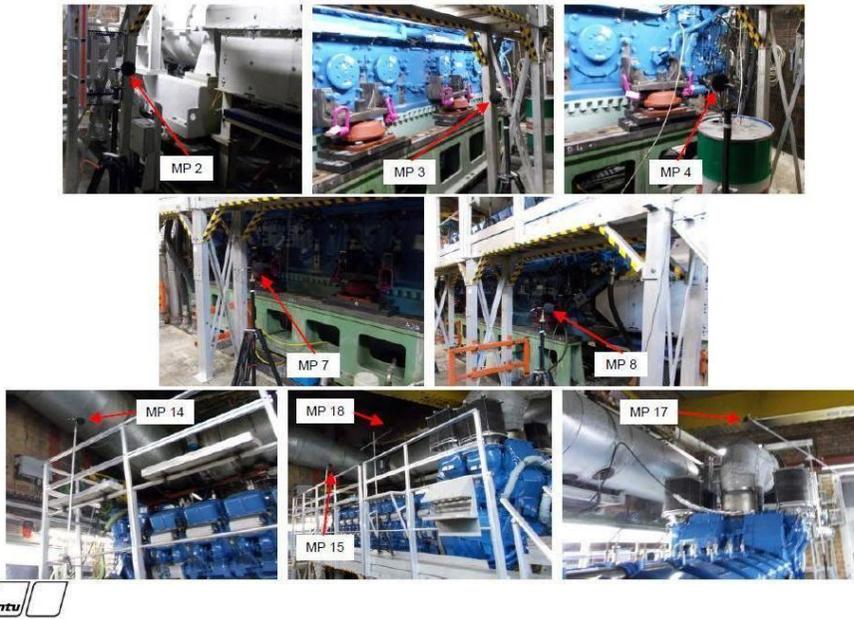
噪音測試報告紀錄-3



Installation of the 20V 8000 M71L in test cell 130 with indication of microphone positions



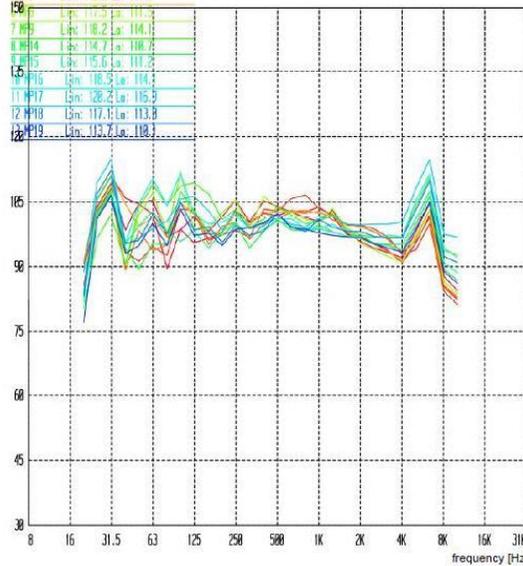
噪音測試報告紀錄-4



噪音測試報告紀錄-5

Airborne Noise Analysis - ISO 6798
 280 0000 M7/L - eng. no. 569100319
 Taiwan Coast Guard - CPU - A1294675
 25.07.19 - MTU test cell 130
 9100 kW @ 1150 rpm - room levels

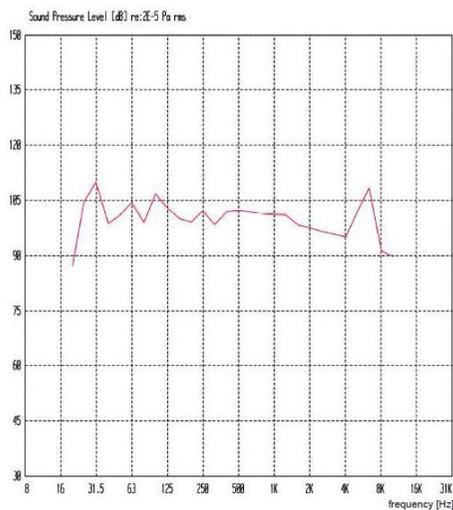
1 MP2	Lin: 116.5	Lo: 111.7
2 MP3	Lin: 116.4	Lo: 111.1
3 MP4	Lin: 115.6	Lo: 112.5
4 MP5	Lin: 114.6	Lo: 110.1
Sound Pressure Level (dB) re: 20 Pa rms		
7 MP7	Lin: 118.2	Lo: 114.1
8 MP14	Lin: 114.7	Lo: 108.8
9 MP15	Lin: 115.6	Lo: 111.2
10 MP16	Lin: 116.3	Lo: 114.1
11 MP17	Lin: 120.2	Lo: 115.9
12 MP18	Lin: 117.1	Lo: 113.8
13 MP19	Lin: 112.7	Lo: 108.7



噪音測試報告紀錄-6

Airborne Noise Analysis - ISO 6798
201 8888 N7/L - eng. no. 569188319
Taiwan Coast Guard - CPU - A1284675
25.87.19 - MTU test cell 138
9188 kW @ 1158 rpm - energy mean noise levels

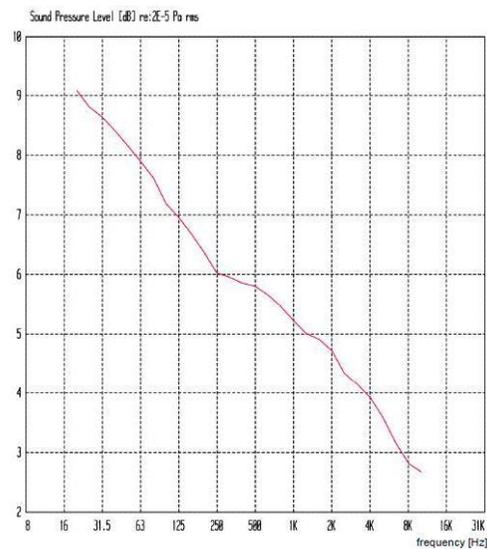
! energy mean noise levels Lin: 116.9 La: 112.7



噪音測試報告紀錄-7

Airborne Noise Analysis - ISO 6798
201 8888 N7/L - eng. no. 569188319
Taiwan Coast Guard - CPU - A1284675
25.87.19 - MTU test cell 138

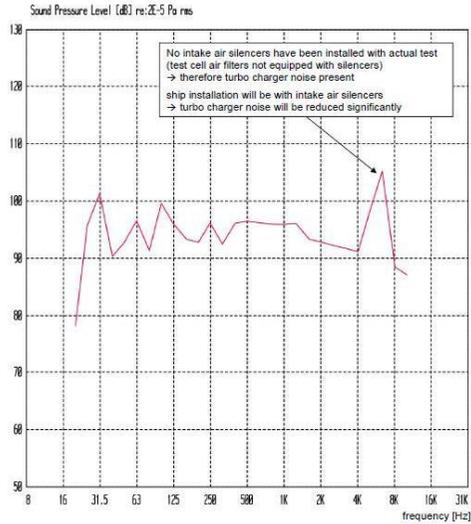
! K2 - free field correction Lin: 28.8 La: 16.3



噪音測試報告紀錄-8

Airborne Noise Analysis - ISO 6798
 280 0800 MTU - eng. no. 569180319
 Taiwan Coast Guard - OPV - A1284675
 25.07.19 - MTU test cell 130
 9100 kW @ 1150 rpm - energy mean free-field levels

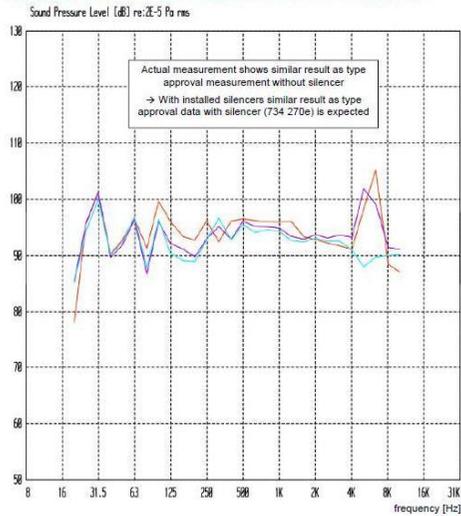
1 energy mean free-field levels Lin: 110.9 Lo: 100.5



噪音測試報告紀錄-9

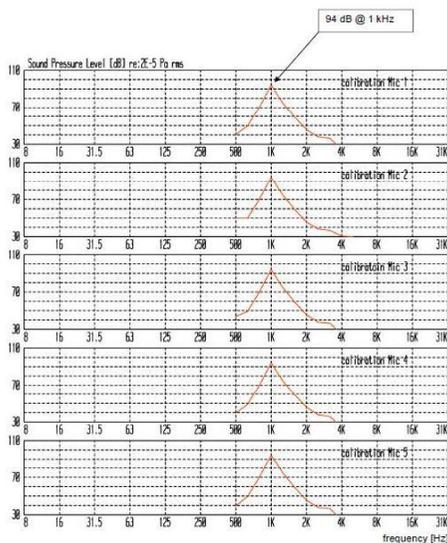
Airborne Noise Analysis - ISO 6798
 280 0800 MTU - eng. no. 569180319
 Taiwan Coast Guard - OPV - A1284675
 25.07.19 - MTU test cell 130
 9100 kW @ 1150 rpm - energy mean free-field levels

1 energy mean free-field levels - eng. no. 569180319 Lin: 110.9 Lo: 100.5
 2 energy mean free-field levels without silencers - type approval data Lin: 103.7 Lo: 107.4
 3 energy mean free-field levels with silencers - type approval data - 734 270e Lin: 100.8 Lo: 104.3



噪音測試報告紀錄-10

Airborne Noise Analysis - ISO 6798
 201 8888 MTU - eng. no. 569108319
 Taiwan Coast Guard - (PV) - A1204675
 25.07.19 - MTU Test cell 130
 calibration signals



噪音測試報告紀錄 - 11

Brüel & Kjær
the international company
 Bülowsvej 307, DK-2850, Søborg, Denmark

ILAC-MRA **DANAK**
Member of ILAC

CERTIFICATE OF CALIBRATION No. CDK1808873 Page 1 of 4

CALIBRATION OF

Calibrator: Brüel & Kjær Type 4231	No. 3011998 B.L.
1x Each adaptor: Brüel & Kjær Type UC-0210	
Pattern Approval: PTB-E 61-4837176	

CUSTOMER

MTU Friedrichshafen GmbH
 Messschulatz 1
 88106 Friedrichshafen
 Germany

CALIBRATION CONDITIONS

Preconditioning: 4 hours at 23°C ± 1°C
 Environmental conditions: Pressure: 101.62 kPa, Humidity: 38 % RH, Temperature: 22.9 °C

SPECIFICATIONS

The Calibrator Brüel & Kjær Type 4231 has been calibrated in accordance with the requirements as specified in IEC 60942:2003 Annex B Class 1. The recalibration assures the traceability to the international unit system SI.

PROCEDURE

The measurements have been performed with the assistance of Brüel & Kjær acoustic calibrator calibration application software (Type 7794 (version 2.5)) by using procedure P_4231_090.

RESULTS

Calibration Made: Calibration as required.

The reported expanded uncertainty is based on the standard uncertainty multiplied by a coverage factor $k = 2$ providing a level of confidence of approximately 95 %. The uncertainty evaluation has been carried out in accordance with EA-402 from wherever originating from the standards, calibration method, effect of environmental conditions and any other trace contribution from the device under calibration.

Date of calibration: 2018-11-06	Date of issue: 2018-11-06
 Lena Wenzel Calibration Technician	 Mikael Oskarsson Approved Signatory

Reproduction of the complete certificate is allowed. Parts of the certificate may only be reproduced after written permission.



噪音測試報告紀錄 - 12



The Calibration Laboratory
Sønderborg 107, DK-2300 Sønder, Denmark

CERTIFICATE OF CALIBRATION

No: CDK1808873

Page 2 of 4

1. Visual Inspection

OK.

2. Measured Values

All stated values are valid at the following environmental reference conditions:

Pressure	101.3 kPa
Temperature	23.0 °C
Relative Humidity	50.0 %

2.1 Sound Pressure Levels

The sound pressure level is measured using the sound calibration comparison method.

Nominal Level [dB]	Accept Limit		Measured Level [dB]	Measurement Uncertainty [dB]
	Lower [dB]	Upper [dB]		
94.00	93.80	94.11	94.00	0.69
114.00	113.89	114.11	113.98	0.69

2.2 Frequency

Nominal Level [Hz]	Accept Limit		Measured Frequency [Hz]	Measurement Uncertainty [Hz]
	Lower [Hz]	Upper [Hz]		
1000	996.10	1009.99	999.58	0.10

2.3 Total Distortion

Distortion mode: TD THD

Calibration Level [dB]	Accept Limit		Measured Distortion [%]	Measurement Uncertainty [%]
	Lower [%]	Upper [%]		
94	2.25	0.34	0.34	0.25
114	2.25	0.33	0.33	0.25

Note: Acceptance limits are reduced by measurement uncertainty to assure that measured value expanded by the actual expanded uncertainty does not exceed the specified limits as stated in the standard.



噪音測試報告紀錄 - 13



The Calibration Laboratory
Sønderborg 107, DK-2300 Sønder, Denmark

CERTIFICATE OF CALIBRATION

No: CDK1808873

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3. Calibration Equipment

	Instrument	Inventory No.
PULSE Analyzer	Brüel & Kjær Type 3560-C	17130430
Transfer Microphone	Brüel & Kjær Type 4192-L-001	124193227
Sound Source Reference	Brüel & Kjær Type 0218	124226034

4. Comments

If none of the measurements is marked as failed the following statement is valid:

As public evidence was available, from a testing organization responsible for approving the results of pattern evaluation tests, to demonstrate that the model of sound calibrator fully conformed to the requirements for pattern evaluation described in Annex A of IEC 60942:2003, the sound calibrator tested is considered to conform to all the class I requirements of IEC 60942:2003.



The Calibration Laboratory
Sønderborg 107, DK-2300 Sønder, Denmark

CERTIFICATE OF CALIBRATION

No: CDK1808873

Page 4 of 4

DANAK

DANAK is the national accreditation body in Denmark in compliance with EU regulation No. 765/2008. DANAK participates in the multilateral agreements for testing and calibration under European co-operation for Accreditation (EA) and under International Laboratory Accreditation Cooperation (ILAC) based on mutual recognition. Accredited test reports and calibration certificates issued by laboratories accredited by DANAK are recognized across borders by members of EA and ILAC equal to test reports and calibration certificates issued by these members' accredited laboratories.

The use of the accreditation mark on test reports and calibration certificates or reference to accreditation documents that the service is provided as an accredited service under the company's trademark accreditation.



噪音測試報告紀錄 - 14

4. MTU 教育訓練中心參訪過程

4.1 緣起及限制

MTU(及其前身)自 1900 起，即以裝配飛船動力單元起家，至今已逾百年歷史，其間經歷第二次世界大戰，於戰火摧殘下仍能順利維持，且動力單元裝配又為高度專業及精密產業，該廠投注於教育訓練及經驗傳承心力實為寶貴借鏡。

本次參訪由 MTU 工程主管專員(Master of Engineering) Anna-Lisa Schonegg 解說及引導，參訪期間因其內部教具教材等多數涉及其商業機密，故全區嚴格禁止攝影(MTU 廠方亦無法提供參訪人園區內影像)，故本次參訪人員雖收穫豐富，然僅能於該中心門口合影。

4.2 動力單元展示

教育訓練中心內陳列多種動力單元，除船用主機外，亦展示火車用主機、渦輪增壓器及混和動力單元等。

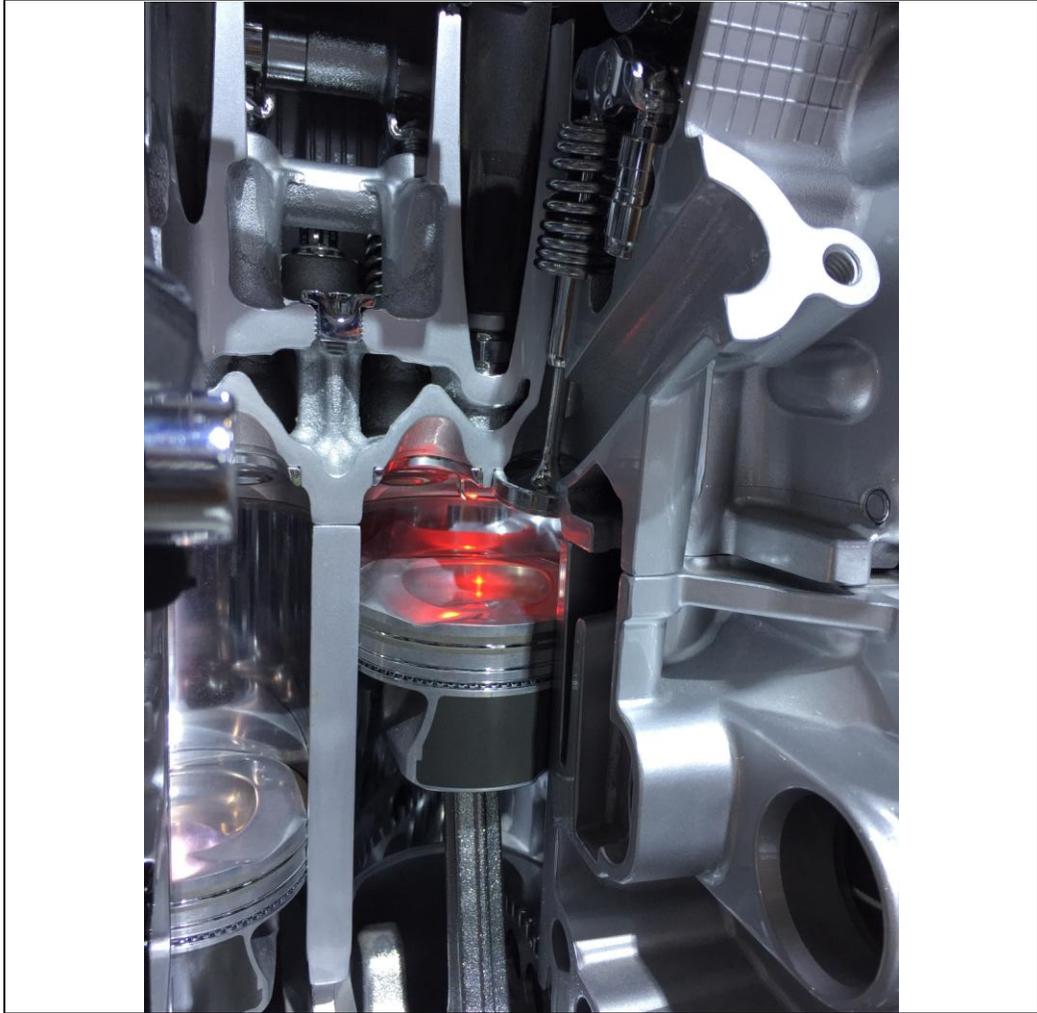
各式主機外觀上差異頗大，主要因所配置空間特性所致。船用主機因配置於船上機艙，機體緊湊方正，以最有效利用三維空間外觀為主。該中心當日僅展試一具火車用主機，且其屬配置於火車車廂底部機型，故外型以扁平設計因應。

教育訓練中心所陳列之船用引擎計有 V208000M90、1163TB93、1163TB94 等多部主機，MTU 人員僅介紹其中部分主機為除役主機，經整備後供教學使用，其整備非僅外觀清潔，各部件經該廠剖析後，亦可見內部等結構均經悉心整理。

4.3 各式機件剖析

教育訓練中心內將多種機件進行剖面，以全覽做動原理，且剖析細緻程度非常高，以主機為例，除汽缸、曲軸及凸輪軸等解剖外，較小部件如活塞頭亦進行縱向解剖以顯現其內部導槽及彈簧等構造，非常細緻。此外亦有廢氣渦輪增壓器、全電動馬達等實機解剖。

主機運行過程中，可能因各種不當因素致使機件損壞，進而影響整體性能表現。教育訓練中心內陳列多種案例之實體零件，例如遭受汽缸內高溫影響之進氣閥門，可見其表面有明顯高溫燒灼之焦斑；受鹽分侵入之作動部件等等。藉由實際物件展示說明以傳承相關痕跡判別。



動力機件剖析範例示意圖(非 MTU 主機)

4.4 MTU 教育訓練中心參訪小結

教育訓練中心除前各段所述內容外，亦展示操俾系統模擬機及為因應未來更嚴格之排放標準(Tier 3)，MTU 所發展之廢氣處理模組的可操作實體等。綜觀全區規劃，可見 MTU 投注其中之大量心力，且範例教材等蒐整耗時甚鉅，除令人歎為觀止外，亦深感自身能量投注之不足。

4.5 教育訓練中心參訪照片



因內部禁止拍照，參訪人員於 MTU 教育訓練中心門口合影

5. 心得及建議

(1) 本次廠試主機品質優異，品管嚴謹，殊值信賴

本次為海洋委員會海巡署艦隊分署 4000 噸級巡防艦 4 艘統包採購案首艦主機工廠測試 (FAT)，為「籌建海巡艦艇發展計畫」之子計畫中最大噸位巡防艦船型，其主機型號為艦隊分署(及其前身海洋巡防總局)史上最大馬力輸出(單部 9,100kw)，廠試過程均依契約要求及船級協會標準實施，測試結果均符合規範要求，且部分優於規範要求之性能測試表現亦正常，品質良好。於測試前會議、廠試過程及廠試後研討等可發現，廠家憑藉豐富產品經驗、長久發展之技能傳承、嚴謹品質控管及充分溝通等，於品質上毫無妥協之堅持，於該公司形象及產品品質等均多有值得借鑒之處，也就是這種對於諸多細節的細膩堅持，造就如今令人欽佩之德國工藝水準。另 MTU 方負責本次廠試作業工程主管專員(Master of Engineering) Anna-Lisa Schonegg 為一年輕女性，身居工程類別主管職位，然我國對於是類工程等普遍仍以男性居多，MTU 任人唯才，落實工作環境與陞遷兩性平權，殊值借鏡效仿。

(2) 教育訓練注重實務經驗累積

參訪 MTU 教育訓練中心期間，實體教材豐富程度令人嘆為觀止。艦隊分署轄下配屬多部艦船，且航海歷史未曾間斷，於船上機件遭遇損害等經驗亦難勝數。MTU 教育訓練中心長期蒐整案例機件及退役主機等，值得艦隊分署及相關教育訓練單位效法。

(3) 為確保新造艦艇品質，未來仍建議持續派員參與工廠測試(FAT)

藉由參與本次廠試，可瞭解他國裝備廠家相關測試前準備方式、品管維護程序及設備性能等，亦可參考借鏡國際企業人才培育方式。未來若仍有規劃是類廠試，建議可安排維修養護及外勤同仁參與，將有助於日後交船之使用及後續維保事宜，促進裝備廠商與機關間雙方合作理解。