出國報告（出國類別：洽公）

赴新加坡進行 LNG 船（PAPUA）計量設備校驗工作

服務機關：台灣中油公司永安液化天然氣廠
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派赴國家/地區：新加坡
出國期間：108/12/08~108/12/11
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摘要（200-300 字）

國內能源選項在政府環境保護政策及非核家園二大議題之下，液化天然氣(LNG)氣化為天然氣(NG)後，可以提供民生及工業的能源所需，台灣自產天然氣(NG)量少，為確保國內供應天然氣之穩定，台灣中油股份有限公司致力分散購氣來源，每年向國外進口大量的液化天然氣。天然氣採購來源除包含馬來西亞、卡達液化天然氣長期採購契約外，之後並陸續與巴布亞紐幾內亞 PNG、澳洲 Ichthys 等其他地區，簽署液化天然氣(LNG)長期採購契約。天然氣輸送乃是以液態形式藉由 LNG 船運送至接收站，而卸收前、後計量方式是經由船上的 CTMS(Custody Transfer Measurement System)設備來計量，計量設備的準確度直接影響計量的結果。

本次至新加坡 Sembcorp Marine 船廠驗證之 LNG 船【PAPUA】，即為執行載運 LNG 至台灣之長期合約船之一。台灣中油股份有限公司與巴布亞紐幾內亞 EMPNG 公司簽訂長達 20 年購氣長約，年合約量可達 120 萬噸，每一紙長期採購契約對滿足國內逐年上升用氣需求都極為重要。

此次 LNG 船（PAPUA）計量設備校正由第三獨立檢驗機構 SGS 執行，校正包括(1)雷達式液位計(Radar Type Level Gauge)、(2)溫度量測系統(Temperature Measuring System)、(3)壓力量測系統(Pressure Measuring System)、(4)浮球式液位計(Float Type Level Gauge)、(5)測斜儀(Inclinometer)，校正後其誤差量需皆在規範要求範圍內以確保交易計量的準確性。

目 次

壹、目的

液化天然氣買賣交易乃是以卸收總熱值作為計價依據，而卸收總熱值則是以卸收量及單位體積 LNG 所含有之熱值來計算出來之結果，因此液化天然氣船於接收站卸收前、後之計量為重要環節之一，將關係到買賣雙方交易之準確性與公正性。本次 LNG 船(PAPUA)於新加坡 Sembcorp Marine 船塢檢修，同時也進行計量設備校驗，而本公司所指派之洽公人員除了可以見證其校正還可以藉由船檢修的參觀過程習得很多知識，實為一次相當難得的經驗。本次校正工作由第三方公證單位 SGS 執行，並且由買方、賣方、船方共同驗證校正結果皆在容許誤差範圍內，以確保買賣計量之準確性，其校正包括(1)雷達式液位計、(2)溫度量測系統、(3)壓力量測系統、(4)測斜儀、(5)浮球式液位計；其校正報告於確認誤無後共同簽署。

貳、過程

一、 出國行程如下：

12月08日：自台灣啟程前往新加坡。

12月09日：至新加坡Sembcorp Marine船塢參與檢視該LNG船(PAPUA)檢修情形，參觀甲板與船橋主要設備檢修情形，並與ExxonMobil、MOL人員、Master of “PAPUA”、SGS代表等討論CTMS計量儀器校正情況及見證相關計量設備之校驗。

12月10日：液位、溫度、壓力、水尺差等各項計量設備有關儀器系統之測試校驗資料研討及彙整。

12月11日：由新加坡返回台灣。

二、 參與計量設備測試及校驗人員機構：

(1)LNG買方代表：

許洲嘉/台灣中油公司永安液化天然氣廠/氣化組/產品管理師

孫基益/台灣中油公司永安液化天然氣廠/氣化組/產品管理師

(2)LNG賣方代表：

ExxonMobil Australia Pty. Ltd：Mr. Adrian Korybutiak

(3)船運公司代表：

Master of “PAPUA”：Captain Neven Sumic

MOL LNG Transport(Europe) Ltd：Mr. Vineet Bhalla

(4)第三獨立檢驗機構代表：

SGS-CTMS Standards Technical Services Co. Ltd：Mr. Kamon Xi

參、具體成效

LNG 船【PAPUA】於 2015 年由中國滬東中華造船所建造完成，該船長度 290.0m，寬度(Breadth)為 46.95m,最大吃水深(Draft)達 11.50m,最大滿載量(Max.Capacity)為 171,800 m^3，最高船速為 19.5 節。此艘船建造有四個 LNG Tank 貨艙，屬於 Membrane Type 密閉壓力系統型式，每個貨艙均裝設有液位計、溫度計、壓力計等感測元件，感測到的數據則傳送至計量電腦，並整合船身的縱向俯仰及橫向傾斜角度，經計算可算得該船 LNG 在卸收前後之載貨量。

另每個貨艙甲板上均設置有浮球式液位計（Float Type Level Gauge)，平時捲收於頂部，並將浮球導管手動閥關閉，避免艙內氣體外漏，此導管設置由貨艙甲板一直到貨艙底部，藉由鋼索做上下導引，以 LNG 浮力使浮球於管內隨液面之上升下降偵測出液位高度，偵測數值可於捲尺視窗直接讀取或由 CCR 之螢幕取得，其主要功能係做為雷達液位計之比較參考，並可做計量備用儀器，當雷達液位計故障時可暫以此浮球式液位計替代。

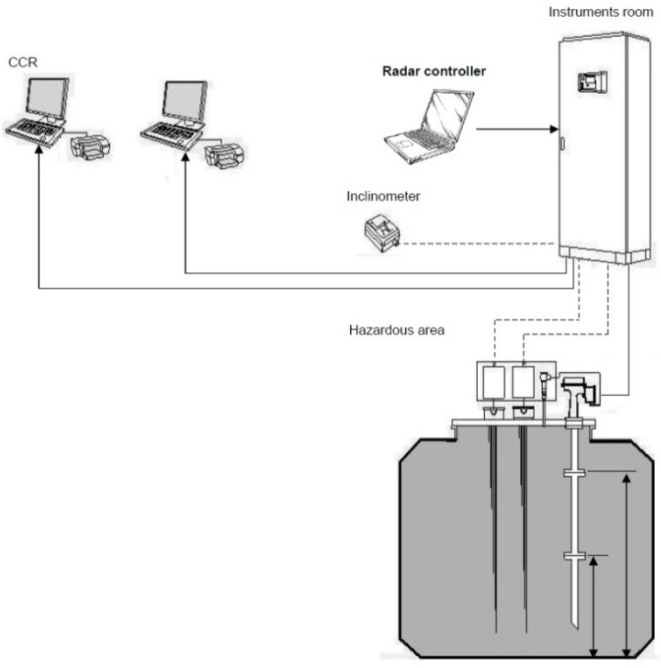
該船 CTMS 計量設備之系統檢測校驗工作，主要由 SGS 公證檢驗機構派代表及船方 MOL 人員執行有關測量及校驗作業。

一、雷達液位量測系統（Radar type level gauge）

(一)測試程序

1.每一貨艙內設有 5 組雷達偵測點，連接原廠雷達控制系統。雷達液位計經由導波管（stand pipe）發射調頻連續波（FMCW），該垂直導波管在固定間距已經設置法蘭，做為已知標位(marker positions are known)，並藉由RTG偵測LNG液面回波（liquid echo）與已知標位回波（marker echo），自動進行連續比對完成雷達液位計校正。

2.艙深液位（Sounding level）是根據量測液面高度、已知管長及板緣厚度等計算數值，藉由雷達偵測各已知艙深液位得到各量測高度，並顯示於 CCR 螢幕，最後以(Level reading)與(Sounding level)之差值為校準結果。



(二)測試結果

1. 摘錄貨艙雷達液位量測系統精確度測試結果如下表，測試結果皆符合規範。

SUMMARY OF TEST RESULT

1. MAIN LEVEL GAUGE (Radar type level gauge)
- Acceptance criteria : +/- 5 mm

	TANK 1	TANK 2	TANK 3	TANK 4
MAIN	0.9 mm	1.0 mm	0.5 mm	0.4 mm

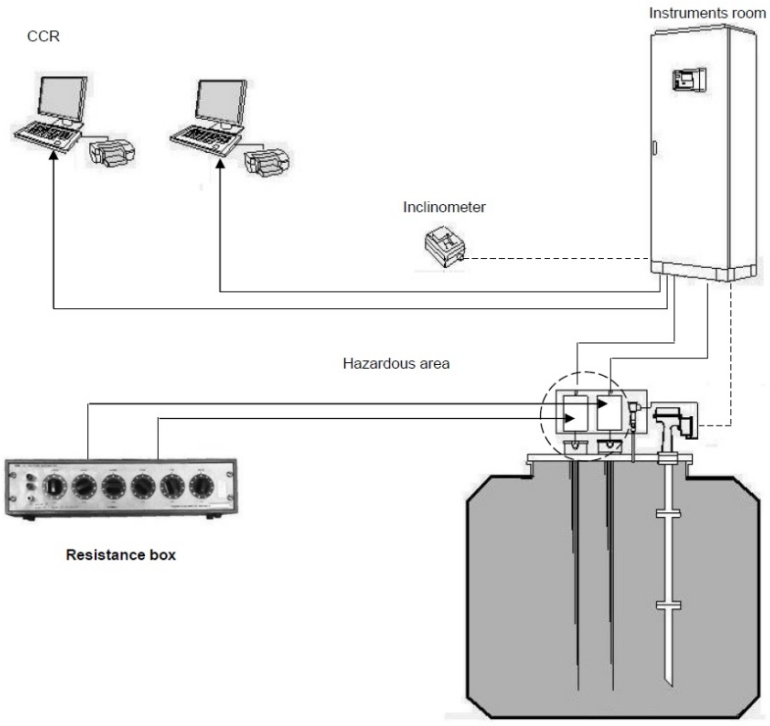
二、溫度計量系統（Temperature Measuring System）

(一)測試程序

1.計算LNG貨載體積時，船上CTMS須取得當時壓力及溫度值做補償運算，以取得最正確體積量。每一貨艙由底部至頂部（Bottom，25%，50%、75%及Top）依照不同高度裝置 5 組溫度感測計(Sensor)，每個溫度感測計皆經SGS檢驗認可。

2.測試時先檢查各溫度感測計(Sensor)組件配線狀況正常。將感測計配線由LON Node處拆開後，再以可變模擬儀器(Resistance Box)接於每一貨艙LON Node溫度信號迴路上，之後由電腦溫度信號輸入端分別發送正確之模擬值，予以對應－165℃、－100℃及0℃等三點各個溫度信號。

3.將模擬信號顯示於CCR螢幕之溫度輸出值，再比對於各溫度感測計(Sensor）出廠測試溫度結果，計算其溫度誤差值。測試項目包含備用溫度感測計。



(二) 測試結果

1.彙整全部貨艙主要溫度感測器及備用溫度感測計之誤差值如下，量測結果皆合乎規範。

	Max. Sensor Error of Various Temp.		
	0℃	-100℃	-165℃
Main Temperature Sensor	0.24℃	0.13℃	0.11℃
Back-Up Temperature Sensor	0.20℃	0.13℃	0.11℃
Min. Requirement/specification	±1.5℃	±0.3 ℃	±0.2 ℃

2. TEMPERATURE MEASURING SYSTEM

- Acceptance criteria -165 ºC ~ -145 ºC : +/- 0.2 ºC @-165°C
-145 ºC ~ -100 ºC : +/- 0.3 ºC @-100°C
-100 ºC ~ 0 ºC : +/- 1.5 ºC @ 0°C

	Temp	TANK 1	TANK 2	TANK 3	TANK 4
MAIN	-165.00	0.04 ºC	0.00 ºC	0.11 ºC	0.08 ºC
	-100.00	0.02 ºC	0.13 ºC	0.06 ºC	0.09 ºC
	0.00	0.24 ºC	0.12 ºC	0.20 ºC	0.04 ºC
BACKUP	-165.00	0.00 ºC	0.04 ºC	0.11 ºC	0.04 ºC
	-100.00	0.13 ºC	0.06 ºC	0.06 ºC	0.02 ºC
	0.00	0.08 ºC	0.04 ºC	0.12 ºC	0.20 ºC

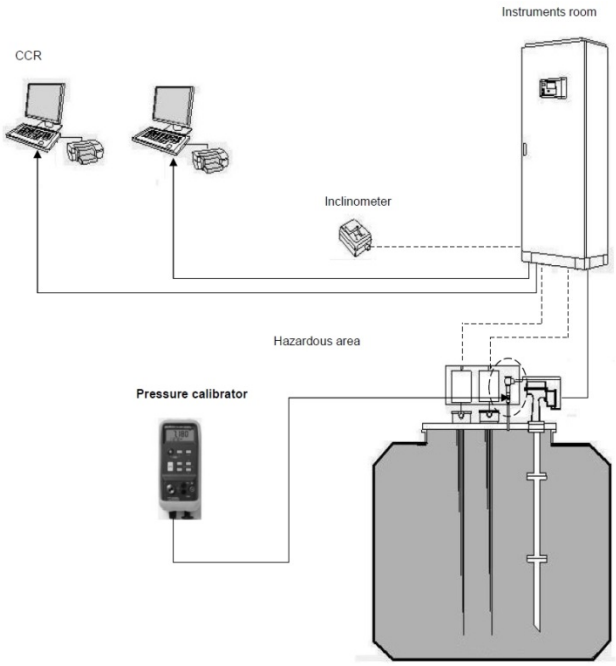
(A) Maximum error of temperature sensors test at time of FAT = 0.17 °C
(B) Maximum error of system at time of SAT = 0.24 °C
Integrated Accuracy (SQRT(A^2+B^2)) = 0.29 °C

三、壓力計量系統（Pressure Measuring System）

(一)測試程序

1.每一貨艙皆設有 1 組壓力感測傳送器。測試時將校準儀器連接至壓力計，由壓力傳輸器依照次序模擬絕對壓力至800mbarA、1100mbarA、1400mbarA信號值，並重覆增壓及減壓程序測試。

2.由 CCR 控制室讀取螢幕顯示壓力值比對測試壓力值予以計算誤差值。



(二)測試結果

1.測試值須在 ±0.5% of Full span(或 ±3 mbar)間之容許範圍內，量測結果皆合乎規範。

2.壓力計量系統精確度之測試紀錄如下表，量測結果皆合乎規範。

3. PRESSURE MEASURING SYSTEM

- Acceptance criteria : +/- 0.5% of Full span (or +/- 3 mbar)

	TANK 1	TANK 2	TANK 3	TANK 4
MAIN	1 mbar	1 mbar	1 mbar	1 mbar
BACKUP	2 mbar	2 mbar	2 mbar	1 mbar

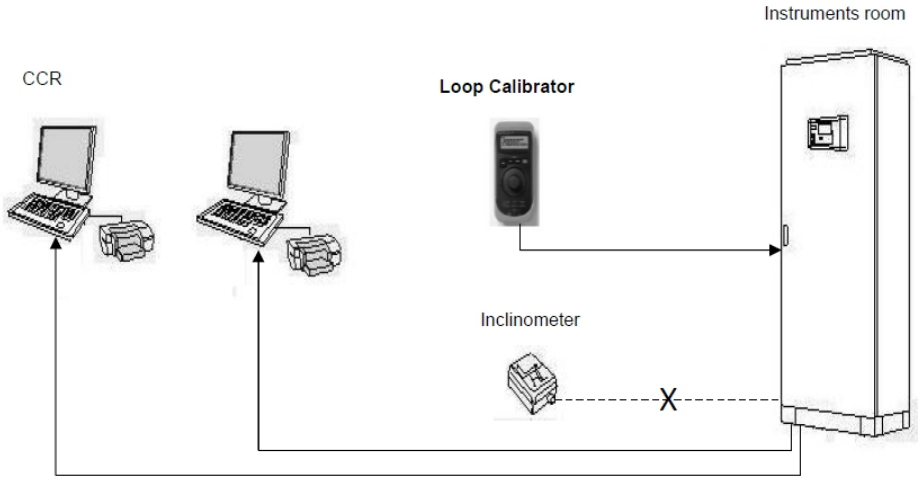
四、測斜儀（Inclinometer）

(一) 測試程序

1.本項測試以4~20 mA標準電流信號產生器接於控制單元迴路上，分別模擬船身之俯仰及傾斜各取3點不同之角度位置的數值，再比較CCR控制室讀取螢幕顯示值與標準電流信號產生器模擬數據之差異結果。

2.將 CTS 系統（Trim / List Measuring System）傾斜儀(Inclinometer)之線路拆開，再把校準儀器連接至傾斜儀端，Trim 部份分別以 4mA、8mA、12mA、16mA 及 20mA 輸出模擬信號，模擬對應船體水尺變化分別是 9.71m（By Head）、4.85m（By Head）、0.00m（Even Keel）、4.85m（By Stern）及 9.71m（By Stern）5 點，逐項比較模擬與實際值校驗誤差。

3.List 部份分別以 4mA、8mA、12mA、16mA 及 20mA 輸出模擬信號，模擬對應船體傾斜變化分別是 5.00 Degree（To Port）、2.50 Degree（To Port）、0.00 Degree（Upright）、2.50 Degree（To Starboard）及 5.00 Degree（To Starboard）5 點，逐項比較模擬與實際值校驗誤差。



(二) 測試結果

1.Trim/List 量測系統之測試紀錄如下表，量測結果皆合乎規範。

TRIM & LIST MEASURING SYSTEM

<Trim indicator system>

Simulated value	Expected Trim		Display		Error	
(mA)	(Meter)		(Meter)		(Meter)	(%)
4 mA	9.71	B/H	9.71	B/H	0.00	0.00
8 mA	4.85	B/H	4.86	B/H	0.01	0.05
12 mA	0.00	E/K	0.01	B/H	0.01	0.05
16 mA	4.85	B/S	4.84	B/S	-0.01	-0.05
20 mA	9.71	B/S	9.70	B/S	-0.01	-0.05
Maximum error			**Meter**		**0.01**	
			% FS		**0.05**	

Range : 9.71 B/S to 9.71 B/H LBP (m): 278

Note) B/S : By stern
E/K : Even Keel
B/H : By head

<List indicator system>

Simulated value	Expected Trim		Display		Error	
(mA)	(Degree)		(Degree)		(Degree)	(%)
4 mA	5.00	P	5.00	P	0.00	0.00
8 mA	2.50	P	2.50	P	0.00	0.00
12 mA	0.00	Upright	0.01	P	0.01	0.10
16 mA	2.50	S	2.49	S	-0.01	-0.10
20 mA	5.00	S	4.99	S	-0.01	-0.10
Maximum error			**Degree**		**0.01**	
			% FS		**0.10**	

Range : -5 Deg to +5 Deg

Note) P : To Port
S : To starboard

4. TRIM/ LIST MEASURING SYSTEM

- Acceptance criteria : +/- 0.5% of Full span

TRIM	0.05 %	LIST	0.10 %

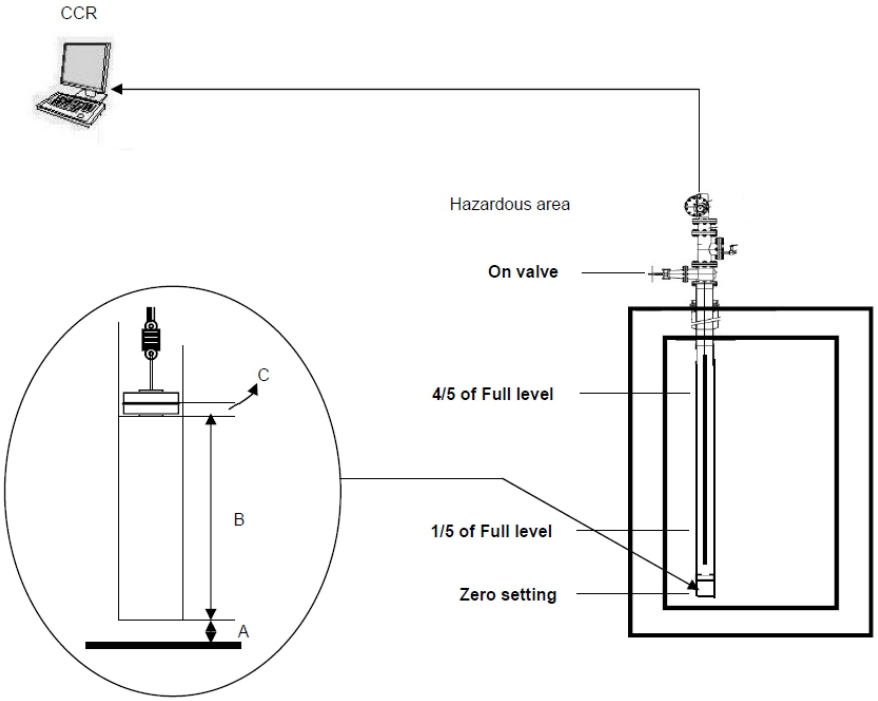
五、浮球液位計系統（Float Level Gauge System）

(一) 測試程序

1.先檢查每一貨艙已知的浮球液位計可以正常操作。

2.將校正過的鋼帶連接到浮球的末端，以30公尺液位高為基準，取得鋼帶的讀數。之後將每一貨艙浮球計高度設定於艙高80%及艙高20%的位置，每個位置皆反覆量測 3 次，按次記錄液位計的讀數及鋼帶的讀數，再經由溫度校正計算結果後，與液位計的讀數做比較。

3.每一貨艙浮球液位計完成測試，其錶頭(Guage head)須由 SGS 人員檢查密封及鉛封，以確保安全性及公正性。



(二)測試結果

1. 摘錄浮球式液位計之測試紀錄如下表，量測結果皆合乎規範。

5. BACKUP LEVEL GAUGE (Float type level gauge)

- Acceptance criteria : +/- 7.5 mm

	TANK 1	TANK 2	TANK 3	TANK 4
LOCAL / REMOTE	5.0 mm	4.0 mm	4.0 mm	2.0 mm

肆、心得及建議

本次出國洽公至新加坡 Sembcorp Marine 船廠，主要見證 LNG 船(PAPUA)計量設備校正工作，藉由過程中了解 LNG 船於接收站是如何準確的公正計量，因此計量設備需要定期校正，以維持買賣雙方交易計量之準確性及公正性。

台灣中油股份有限公司永安液化天然氣廠，108 年 LNG 卸收船次可達 155 艘，LNG 進口量 975 萬噸以上。未來，為因應政府非核家園、環境保護及保護人民健康的政策導向下，台灣國內的發電用能源中，天然氣的比重將持續增加，因此每艘 LNG 船的計量設備之準確性，對於買賣雙方而言，都是極其重要的。

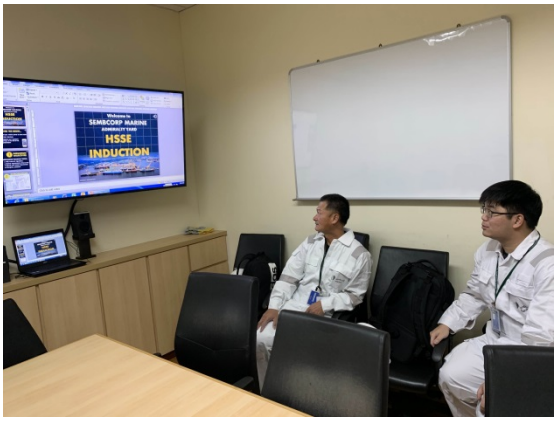
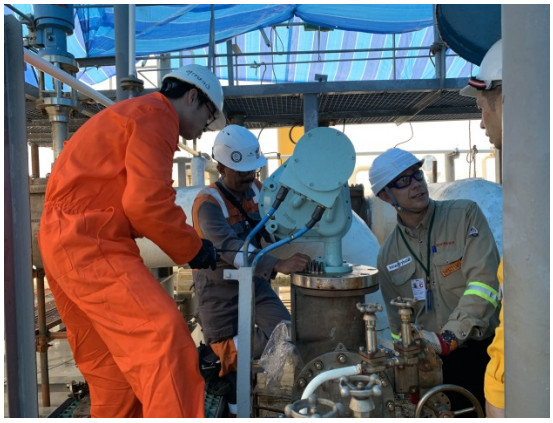
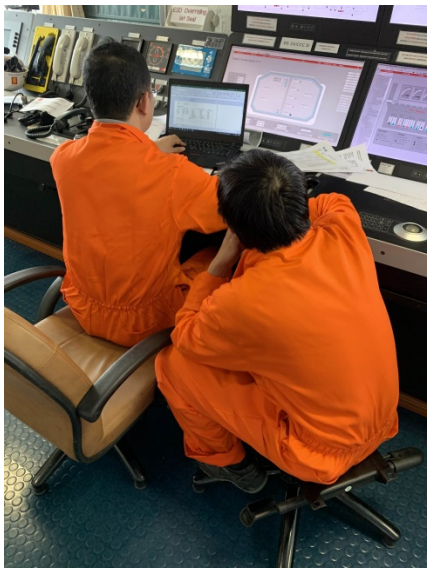
液化天然氣第三接收站尚未啟用之前，由國外購入的 LNG 仍然只能以現有的接收站來做卸收，使得永安液化天然氣廠卸船船次及卸收量每年逐步上昇，接船主管(Loading Master)在此狀況下，除了要熟悉廠內的設備之外，也要對船上的設備及運作原理有所瞭解，不但可以使天然氣廠順利生產操作，並且可以讓 LNG 卸收之過程順利進行。

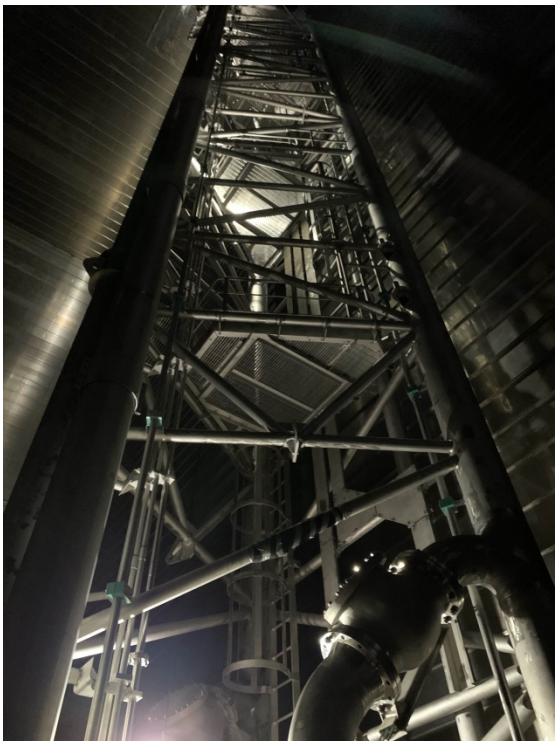
在進入台灣中油永安液化天然氣廠實習及擔任接船主管(Loading Master)職務期間，因洽公才使得有機會進入 LNG Membrane Type 密閉壓力型式貨艙內部，Tank 內部是令人驚嘆且甚為壯觀，因進入 Tank 是採用直式爬梯，過程需相當的體力是一大挑戰，雖過程辛苦，甚至身上分不出是雨水還是汗水，但可以親眼見到 CTMS 所使用之測量感測器和了解校驗等過程，並親身體驗在 Tank 內部是多難得的經驗，如未來有機會的話，可建議讓每一位從事接船相關業務人員可至船上見證儀器之校驗過程及參與貨艙參觀，相信這對未來 LNG 卸收過程中，參與的相關人員都會有相當大的幫助。

本次洽公相關照片如下簡略所示。

Sembcorp Marine 船廠報到處

LNG 船 PAPUA 工作之固定船梯

	
進入船廠前之安全告知(以影片解說)	上完職業安全健康講習所給的識別卡
	
於LNG船CCR討論CTMS等儀器校驗進度	校驗相關人員於現場校驗CTMS等儀器
	
SGS 人員於 CCR 彙整校驗報告	校驗壓力計

	
貨艙Cargo Pump及Check Valve	貨艙直梯與管路儀器泵浦支撐結構總成
	
LNG船PAPUA貨艙內部Membrane Type	參觀貨艙後與EMPNG人員在貨艙底部合影

伍、附件(LNG 船 CTMS 計量儀校驗結果完整報告)

SGS

REVERIFICATION

OF

CUSTODY TRANSFER SYSTEM

LNGC " PAPUA"

(IMO NO. : 9613135)

CERTIFICATE NO. OWONB1900863

PLACE : SEMBCORP MARINE
IN SINGAPORE

DATE : 8th, 9th December, 2019

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CONTENTS

1. CERTIFICATE OF CTS REVERIFICATION

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CERTIFICATE NO. : OWONB1900863

This is to certify that we, undersigned, did at the request of :

MOL LNG Transport (Europe) Ltd

verify accuracy of the custody transfer system of the LNG vessel with following details

Vessel Name	: PAPUA
IMO No.	: 9613135
Owner	: AQUARIUS LNG SHIPPING LIMITED
No. of cargo tanks	: 4
Cargo tank material	: GTT No.96 / Invar Membrane

We confirm that

1) The accuracy test was executed at Sembcorp Marine Sembawang Yard, Singapore on 8th & 9th December, 2019.

2) Tests were performed for the following systems in all 4 tanks

Test items	Specification		Test result (Max. Error)
Radar level gauge	+/- 5 mm		1 mm
Temperature measuring system	+/- 0.2 °C @ -165 °C +/- 0.3 °C @ -100 °C +/- 1.5 °C @ 0 °C	FAT (A)	0.17 ºC
		SAT (B)	0.24 ºC
	Integrated accuracy $=SQRT(A^2+B^2)$		0.29 ºC
Pressure gauges	+/- 0.5% of F.S or +/- 3 mbarA		0.33% or 2 mbarA
Trim. List measuring systems	0.5% of F.S		0.10%
Float level gauges	+/- 7.5mm		5.0 mm

3) The custody transfer system for the temperature, pressure and level were accurate within the tolerance set by Japanese Authorities's and maker's specification.

4) The measuring equipments used for the accuracy test have individual calibration certificates directly traceable to National Standards.

SGS - CSTC OIL, GAS & CHEMICALS SERVICES SGS 03

For and behalf
SGS China Co.,Ltd.

Henry Li / Manager
OG&C, Calibration Service
11th December,2019

2. FIELD DATA SHEET

SUMMARY OF TEST RESULT

1. MAIN LEVEL GAUGE (Radar type level gauge)
- Acceptance criteria : +/- 5 mm

	TANK 1	TANK 2	TANK 3	TANK 4
MAIN	0.9 mm	1.0 mm	0.5 mm	0.4 mm

2. TEMPERATURE MEASURING SYSTEM
- Acceptance criteria -165 ºC ~ -145 ºC : +/- 0.2 ºC @-165°C
  -145 ºC ~ -100 ºC : +/- 0.3 ºC @-100°C
  -100 ºC ~ 0 ºC : +/- 1.5 ºC @ 0°C

	Temp	TANK 1	TANK 2	TANK 3	TANK 4
MAIN	-165.00	0.04 ºC	0.00 ºC	0.11 ºC	0.08 ºC
	-100.00	0.02 ºC	0.13 ºC	0.06 ºC	0.09 ºC
	0.00	0.24 ºC	0.12 ºC	0.20 ºC	0.04 ºC
BACKUP	-165.00	0.00 ºC	0.04 ºC	0.11 ºC	0.04 ºC
	-100.00	0.13 ºC	0.06 ºC	0.06 ºC	0.02 ºC
	0.00	0.08 ºC	0.04 ºC	0.12 ºC	0.20 ºC

(A) Maximum error of temperature sensors test at time of FAT = 0.17 ℃
(B) Maximum error of system at time of SAT = 0.24 ℃
Integrated Accuracy (SQRT(A^2+B^2)) = 0.29 ℃

3. PRESSURE MEASURING SYSTEM
- Acceptance criteria : +/- 0.5% of Full span (or +/- 3 mbar)

	TANK 1	TANK 2	TANK 3	TANK 4
MAIN	1 mbar	1 mbar	1 mbar	1 mbar
BACKUP	2 mbar	2 mbar	2 mbar	1 mbar

4. TRIM/ LIST MEASURING SYSTEM
- Acceptance criteria : +/- 0.5% of Full span

TRIM	0.05 %	LIST	0.10 %

5. BACKUP LEVEL GAUGE (Float type level gauge)
- Acceptance criteria : +/- 7.5 mm

	TANK 1	TANK 2	TANK 3	TANK 4
LOCAL / REMOTE	5.0 mm	4.0 mm	4.0 mm	2.0 mm

SUMMARY OF SERIAL NUMBER

1. MAIN LEVEL GAUGE

- Maker : KONGSBERG MARITIME AS. - Type : Radar level gauge

S/N	TANK 1	TANK 2	TANK 3	TANK 4
MAIN	glpx 1169	glpx 1170	glpx 1171	glpx 1172

2. TEMPERATURE MEASURING SYSTEM

- Maker : KONGSBERG MARITIME AS. - System : Autro Cargo 2000 CTS

<Sensors>

- Maker : KONGSBERG MARITIME AS. - Element : PT 100 Ohm
- Number : 10 pcs / tank, total 40 pcs. - Range : -200 ºC ~ +100 ºC

S/N	POSITION	TANK 1	TANK 2	TANK 3	TANK 4
MAIN	T5(TOP)	7706	7708	7710	7745
	T4(75%)	7714	7716	7718	7720
	T3(50%)	7722	7724	7726	7728
	T2(25%)	7730	7732	7734	7736
	T1(BTM)	7738	7740	7742	7744
BACKUP	T5(TOP)	7705	7707	7709	7711
	T4(75%)	7713	7715	7717	7719
	T3(50%)	7721	7723	7725	7727
	T2(25%)	7729	7731	7733	7735
	T1(BTM)	7737	7739	7741	7743

3. PRESSURE MEASURING SYSTEM

- Maker : KONGSBERG MARITIME AS. - System : Autro Cargo 2000 CTS
- Type : Absolute pressure - Range : 800 mbar~ 1400 mbar

S/N	TANK 1	TANK 2	TANK 3	TANK 4
MAIN	134367	134227	134371	134225
BACKUP	160941	135748	134372	134382

Note) CT 1B pressure sensor replace with sn 160941 instead of sn 134380.

4. TRIM & LIST MEASURING SYSTEM

- Maker : KONGSBERG MARITIME AS. - System : Autro Cargo 2000 CTS

<Inclinometer>

- Maker : Sensorex Inc. - Model No. : 690 641 428 B
- Serial No. : 0055 - Range : +/- 5 º (X axis), +/- 2 º (Y axis)

5. BACKUP LEVEL GAUGE

- Maker : Whessoe Europe Ltd. - Type : Float level gauge

S/N	TANK 1	TANK 2	TANK 3	TANK 4
Transmitter	MG2142-01	MG2142-02	MG2142-03	MG2142-04

ACCEPTANCE OF TEST RESULT

This is to confirm that all verification test carried out for **LNGC "PAPUA"** at Sembcorp Marine(Sembawang Yard) in Singapore on 8th and 9th Dec, 2019, complied with the procedures witnessed by following personnel.
All results are within the tolerance, comply with the CTS requirements at time of test.

Adrian Korybutiak
ExxonMobil Australia

Vineet Bhalla
MOL LNG Transport (Europe) Ltd

Neven Sumic
Master of PAPUA

PAPUA MASTER IMO No: 9613135 HONG KONG

Kamen Yu
SGS China

REMARKS

All test results are within tolerance s for both Kongsberg and Whessoe.

Pressure Sensor 1B replace with sn 160941 instead of sn 134380

(1) ACCURACY TEST OF RADAR TYPE LEVEL GAUGE

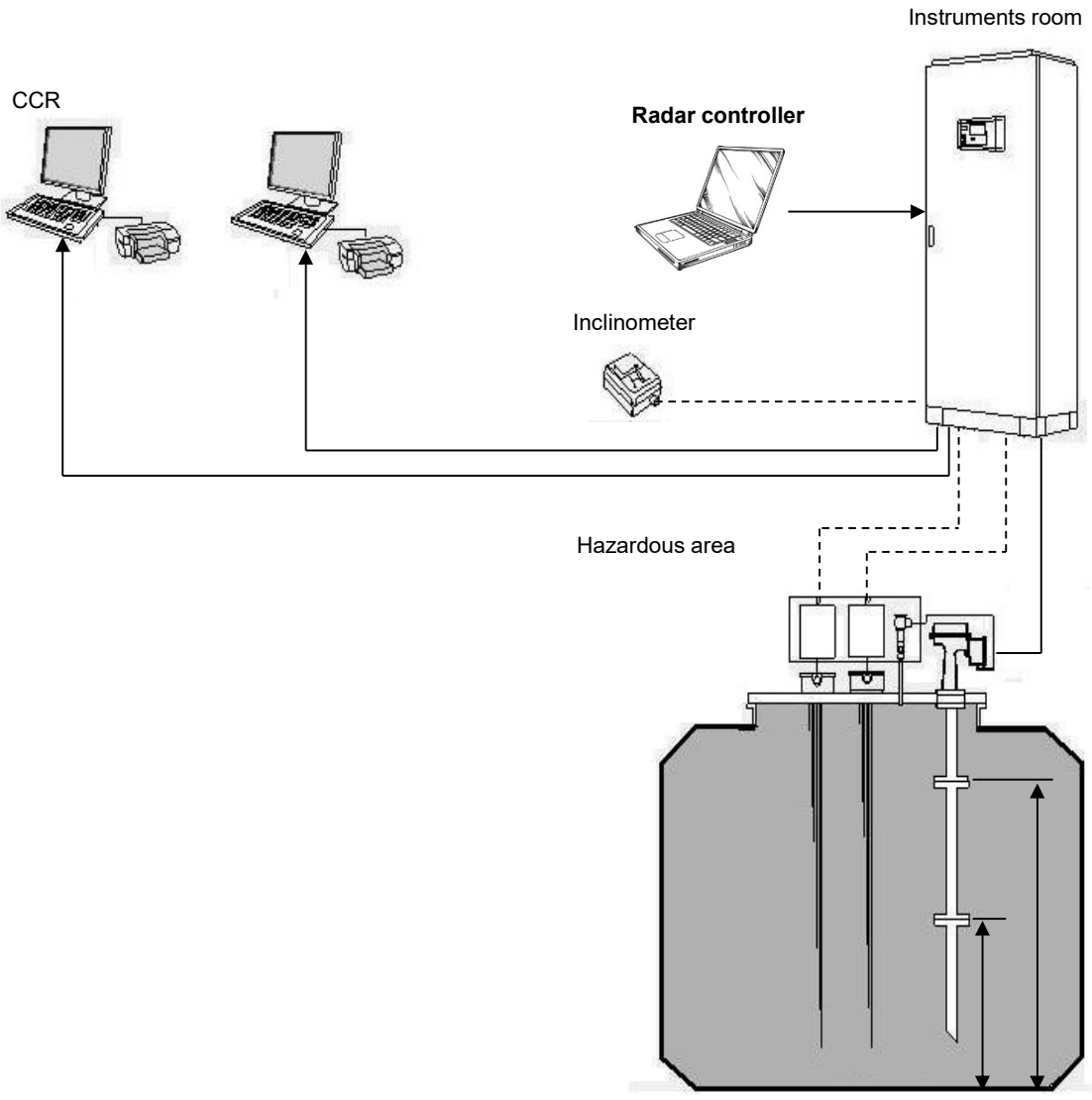
1. Purpose : Verify accuracy of level measurement by radar gauge.

2. Procedure
- Connect manufacturer's radar controller to the system.
- Measure level of each PTFE disc in the stand pipe by radar gauge.
- Calculate expected level of disc using data of pipe length.

Expected level = Total gauge height - (Pipe length + Flange + PTFE offset)

- Compare displayed level with expected level.

3. Acceptance criteria : +/- 5 mm



RADAR TYPE LEVEL GAUGE

Serial No.: glpx 1169
TGH : 30445 mm

All unit in mm.

Tank No.	Pipe ID	Pipe Section	Pipe length @ 20 ºC	Ullage level	Sounding level (S)	Level reading (L)	Difference (L - S)
1	A	1	2800.8	2827.9	27617.1	27617	**-0.1**
						27617	**-0.1**
						27617	**-0.1**
		2	6009.6	8836.9	21608.1	21609	**0.9**
						21609	**0.9**
						21609	**0.9**
		3	6009.7	14846.6	15598.4	15599	**0.6**
						15599	**0.6**
						15599	**0.6**
		4	6011.7	20858.3	9586.7	9586	**-0.7**
						9586	**-0.7**
						9586	**-0.7**
		5	6009.8	26868.1	3576.9	3577	**0.1**
						3577	**0.1**
						3577	**0.1**

Maximum deviation: **0.9** **mm**

Serial No.: glpx 1170
TGH : 30422 mm

All unit in mm.

Tank No.	Pipe ID	Pipe Section	Pipe length @ 20 ºC	Ullage level	Sounding level (S)	Level reading (L)	Difference (L - S)
2	B	1	2799.6	2826.7	27595.3	27595	**-0.3**
						27595	**-0.3**
						27595	**-0.3**
		2	6009.8	8835.9	21586.1	21586	**-0.1**
						21586	**-0.1**
						21586	**-0.1**
		3	6009.7	14845.6	15576.4	15577	**0.6**
						15577	**0.6**
						15577	**0.6**
		4	6009.4	20855.0	9567.0	9566	**-1.0**
						9566	**-1.0**
						9566	**-1.0**
		5	6008.9	26863.9	3558.1	3558	**-0.1**
						3558	**-0.1**
						3558	**-0.1**

Maximum deviation: **1** **mm**

RADAR TYPE LEVEL GAUGE

Serial No.: glpx 1171
TGH : 30436 mm

All unit in mm.

Tank No.	Pipe ID	Pipe Section	Pipe length @ 20 ºC	Ullage level	Sounding level (S)	Level reading (L)	Difference (L - S)
3	C	1	2799.4	2826.5	27609.5	27610	**0.5**
						27610	**0.5**
						27610	**0.5**
		2	6009.4	8835.3	21600.7	21601	**0.3**
						21601	**0.3**
						21601	**0.3**
		3	6010.1	14845.4	15590.6	15591	**0.4**
						15591	**0.4**
						15591	**0.4**
		4	6009.6	20855.0	9581.0	9581	**0.0**
						9581	**0.0**
						9581	**0.0**
		5	6009.6	26864.6	3571.4	3571	**-0.4**
						3571	**-0.4**
						3571	**-0.4**

Maximum deviation: **0.5** **mm**

Serial No.: glpx 1172
TGH : 30443 mm

All unit in mm.

Tank No.	Pipe ID	Pipe Section	Pipe length @ 20 ºC	Ullage level	Sounding level (S)	Level reading (L)	Difference (L - S)
4	D	1	2799.8	2826.9	27616.1	27616	**-0.1**
						27616	**-0.1**
						27616	**-0.1**
		2	6009.8	8836.1	21606.9	21607	**0.1**
						21607	**0.1**
						21607	**0.1**
		3	6009.3	14845.4	15597.6	15598	**0.4**
						15598	**0.4**
						15598	**0.4**
		4	6009.6	20855.0	9588.0	9588	**0.0**
						9588	**0.0**
						9588	**0.0**
		5	6009.4	26864.4	3578.6	3579	**0.4**
						3579	**0.4**
						3579	**0.4**

Maximum deviation: **0.4** **mm**

(2) ACCURACY TEST OF TEMPERATURE MEASURING SYSTEM

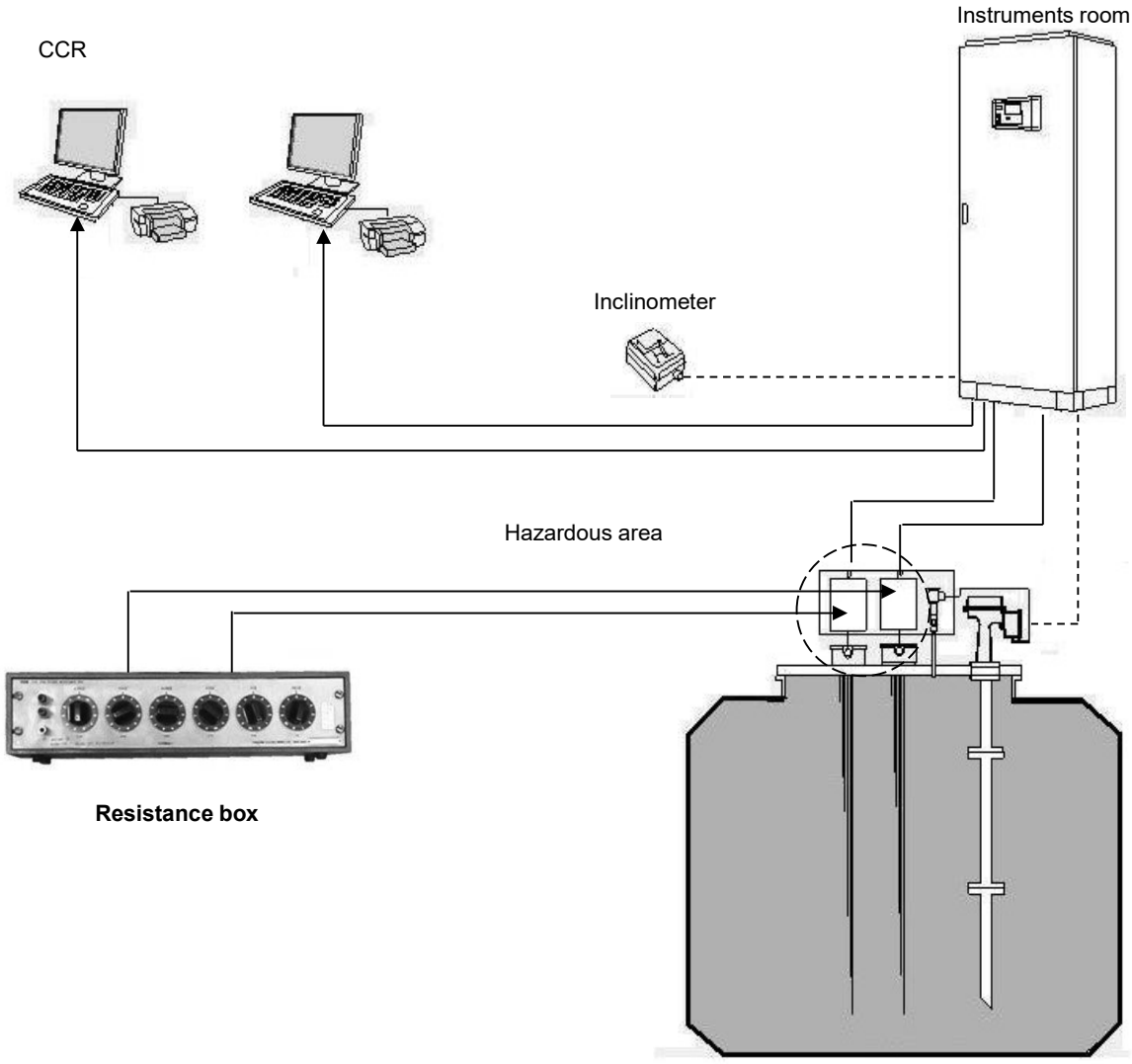
1. Purpose : Verify the cargo temperature input channel LON node and processing chain.

2. Procedure
- Disconnect sensor cable from LON node.
- Connect temperature simulator (Resistance box) to LON node.
- Simulate temperature -165 ºC, -100 ºC, 0 ºC.
- Compare the temperature output from display taking the correction factor of each sensor.

! Each temperature sensor has its calibration certificate with specified offset value issued by manufacturer. Correct offset of all sensors should be in the system, it will be confirmed by SGS inspectors.

3. Acceptance criteria:

-165 ºC ~ -145 ºC :	+/- 0.2 ºC
-145 ºC ~ -100 ºC :	+/- 0.3 ºC
-100 ºC ~ 0 ºC :	+/- 1.5 ºC



TEMPERATURE MEASURING SYSTEM

Tank No. 1

<Main sensors> All unit in ºC.

Sensor position	Serial No.	Offset value (ºC)	Input Temp (ºC)	Simulated Temp (º C)	Display	
					CCR (ºC)	Error (ºC)
T5 (TOP)	7706	0.14	-165.00	-164.86	-164.82	0.04
			-100.00	-99.86	-99.84	0.02
			0.00	0.14	0.34	0.20
T4 (75%)	7714	0.16	-165.00	-164.84	-164.84	0.00
			-100.00	-99.84	-99.82	0.02
			0.00	0.16	0.36	0.20
T3 (50%)	7722	0.14	-165.00	-164.86	-164.86	0.00
			-100.00	-99.86	-99.84	0.02
			0.00	0.14	0.38	0.24
T2 (25%)	7730	0.15	-165.00	-164.85	-164.85	0.00
			-100.00	-99.85	-99.83	0.02
			0.00	0.15	0.35	0.20
T1 (BTM)	7738	0.16	-165.00	-164.84	-164.84	0.00
			-100.00	-99.84	-99.82	0.02
			0.00	0.16	0.36	0.20
Maximum error (ºC)			**-165.00**		**0.04**	
			-100.00		**0.02**	
			0.00		**0.24**	

<Backup sensors> All unit in ºC.

Sensor position	Serial No.	Offset value (ºC)	Input Temp (ºC)	Simulated Temp (º C)	Display	
					CCR (ºC)	Error (ºC)
T5 (TOP)	7705	0.17	-165.00	-164.83	-164.83	0.00
			-100.00	-99.83	-99.92	0.09
			0.00	0.17	0.09	0.08
T4 (75%)	7713	0.15	-165.00	-164.85	-164.85	0.00
			-100.00	-99.85	-99.94	0.09
			0.00	0.15	0.07	0.08
T3 (50%)	7721	0.16	-165.00	-164.84	-164.84	0.00
			-100.00	-99.84	-99.97	0.13
			0.00	0.16	0.08	0.08
T2 (25%)	7729	0.14	-165.00	-164.86	-164.86	0.00
			-100.00	-99.86	-99.99	0.13
			0.00	0.14	0.06	0.08
T1 (BTM)	7737	0.16	-165.00	-164.84	-164.84	0.00
			-100.00	-99.84	-99.97	0.13
			0.00	0.16	0.08	0.08
Maximum error (ºC)			**-165.00**		**0.00**	
			-100.00		**0.13**	
			0.00		**0.08**	

TEMPERATURE MEASURING SYSTEM

Tank No. 2

<Main sensors> All unit in ºC.

Sensor position	Serial No.	Offset value (ºC)	Input Temp (ºC)	Simulated Temp (ºC)	Display	
					CCR (ºC)	Error (ºC)
T5 (TOP)	7708	0.15	-165.00	-164.85	-164.85	0.00
			-100.00	-99.85	-99.98	0.13
			0.00	0.15	0.07	0.08
T4 (75%)	7716	0.16	-165.00	-164.84	-164.84	0.00
			-100.00	-99.84	-99.97	0.13
			0.00	0.16	0.08	0.08
T3 (50%)	7724	0.16	-165.00	-164.84	-164.84	0.00
			-100.00	-99.84	-99.97	0.13
			0.00	0.16	0.08	0.08
T2 (25%)	7732	0.15	-165.00	-164.85	-164.85	0.00
			-100.00	-99.85	-99.98	0.13
			0.00	0.15	0.07	0.08
T1 (BTM)	7740	0.15	-165.00	-164.85	-164.85	0.00
			-100.00	-99.85	-99.98	0.13
			0.00	0.15	0.03	0.12
Maximum error (ºC)			**-165.00**		**0.00**	
			-100.00		**0.13**	
			0.00		**0.12**	

<Backup sensors> All unit in ºC.

Sensor position	Serial No.	Offset value (ºC)	Input Temp (ºC)	Simulated Temp (ºC)	Display	
					CCR (ºC)	Error (ºC)
T5 (TOP)	7707	0.15	-165.00	-164.85	-164.81	0.04
			-100.00	-99.85	-99.91	0.06
			0.00	0.15	0.15	0.00
T4 (75%)	7715	0.15	-165.00	-164.85	-164.81	0.04
			-100.00	-99.85	-99.91	0.06
			0.00	0.15	0.11	0.04
T3 (50%)	7723	0.15	-165.00	-164.85	-164.81	0.04
			-100.00	-99.85	-99.91	0.06
			0.00	0.15	0.15	0.00
T2 (25%)	7731	0.15	-165.00	-164.85	-164.85	0.00
			-100.00	-99.85	-99.91	0.06
			0.00	0.15	0.15	0.00
T1 (BTM)	7739	0.16	-165.00	-164.84	-164.80	0.04
			-100.00	-99.84	-99.90	0.06
			0.00	0.16	0.16	0.00
Maximum error (ºC)			**-165.00**		**0.04**	
			-100.00		**0.06**	
			0.00		**0.04**	

TEMPERATURE MEASURING SYSTEM

Tank No. 3

<Main sensors> All unit in ºC.

Sensor position	Serial No.	Offset value (ºC)	Input Temp (ºC)	Simulated Temp (ºC)	Display	
					CCR (ºC)	Error (ºC)
T5 (TOP)	7710	0.17	-165.00	-164.83	-164.72	0.11
			-100.00	-99.83	-99.77	0.06
			0.00	0.17	0.37	0.20
T4 (75%)	7718	0.15	-165.00	-164.85	-164.81	0.04
			-100.00	-99.85	-99.83	0.02
			0.00	0.15	0.31	0.16
T3 (50%)	7726	0.15	-165.00	-164.85	-164.77	0.08
			-100.00	-99.85	-99.83	0.02
			0.00	0.15	0.31	0.16
T2 (25%)	7734	0.15	-165.00	-164.85	-164.77	0.08
			-100.00	-99.85	-99.83	0.02
			0.00	0.15	0.35	0.20
T1 (BTM)	7742	0.15	-165.00	-164.85	-164.77	0.08
			-100.00	-99.85	-99.83	0.02
			0.00	0.15	0.31	0.16
Maximum error (ºC)			**-165.00**		**0.11**	
			-100.00		**0.06**	
			0.00		**0.20**	

<Backup sensors> All unit in ºC.

Sensor position	Serial No.	Offset value (ºC)	Input Temp (ºC)	Simulated Temp (ºC)	Display	
					CCR (ºC)	Error (ºC)
T5 (TOP)	7709	0.15	-165.00	-164.85	-164.74	0.11
			-100.00	-99.85	-99.83	0.02
			0.00	0.15	0.27	0.12
T4 (75%)	7717	0.15	-165.00	-164.85	-164.77	0.08
			-100.00	-99.85	-99.87	0.02
			0.00	0.15	0.23	0.08
T3 (50%)	7725	0.14	-165.00	-164.86	-164.78	0.08
			-100.00	-99.86	-99.88	0.02
			0.00	0.14	0.22	0.08
T2 (25%)	7733	0.15	-165.00	-164.85	-164.77	0.08
			-100.00	-99.85	-99.87	0.02
			0.00	0.15	0.23	0.08
T1 (BTM)	7741	0.14	-165.00	-164.86	-164.75	0.11
			-100.00	-99.86	-99.92	0.06
			0.00	0.14	0.22	0.08
Maximum error (ºC)			**-165.00**		**0.11**	
			-100.00		**0.06**	
			0.00		**0.12**	

TEMPERATURE MEASURING SYSTEM

Tank No. 4

<Main sensors> All unit in ºC.

Sensor position	Serial No.	Offset value (ºC)	Input Temp (ºC)	Simulated Temp (º C)	Display	
					CCR (ºC)	Error (ºC)
T5 (TOP)	7745	0.15	-165.00	-164.85	-164.85	0.00
			-100.00	-99.85	-99.94	0.09
			0.00	0.15	0.11	0.04
T4 (75%)	7720	0.15	-165.00	-164.85	-164.81	0.04
			-100.00	-99.85	-99.94	0.09
			0.00	0.15	0.11	0.04
T3 (50%)	7728	0.14	-165.00	-164.86	-164.82	0.04
			-100.00	-99.86	-99.92	0.06
			0.00	0.14	0.10	0.04
T2 (25%)	7736	0.17	-165.00	-164.83	-164.75	0.08
			-100.00	-99.83	-99.89	0.06
			0.00	0.17	0.13	0.04
T1 (BTM)	7744	0.15	-165.00	-164.85	-164.81	0.04
			-100.00	-99.85	-99.91	0.06
			0.00	0.15	0.15	0.00
Maximum error (ºC)			**-165.00**		**0.08**	
			-100.00		**0.09**	
			0.00		**0.04**	

<Backup sensors> All unit in ºC.

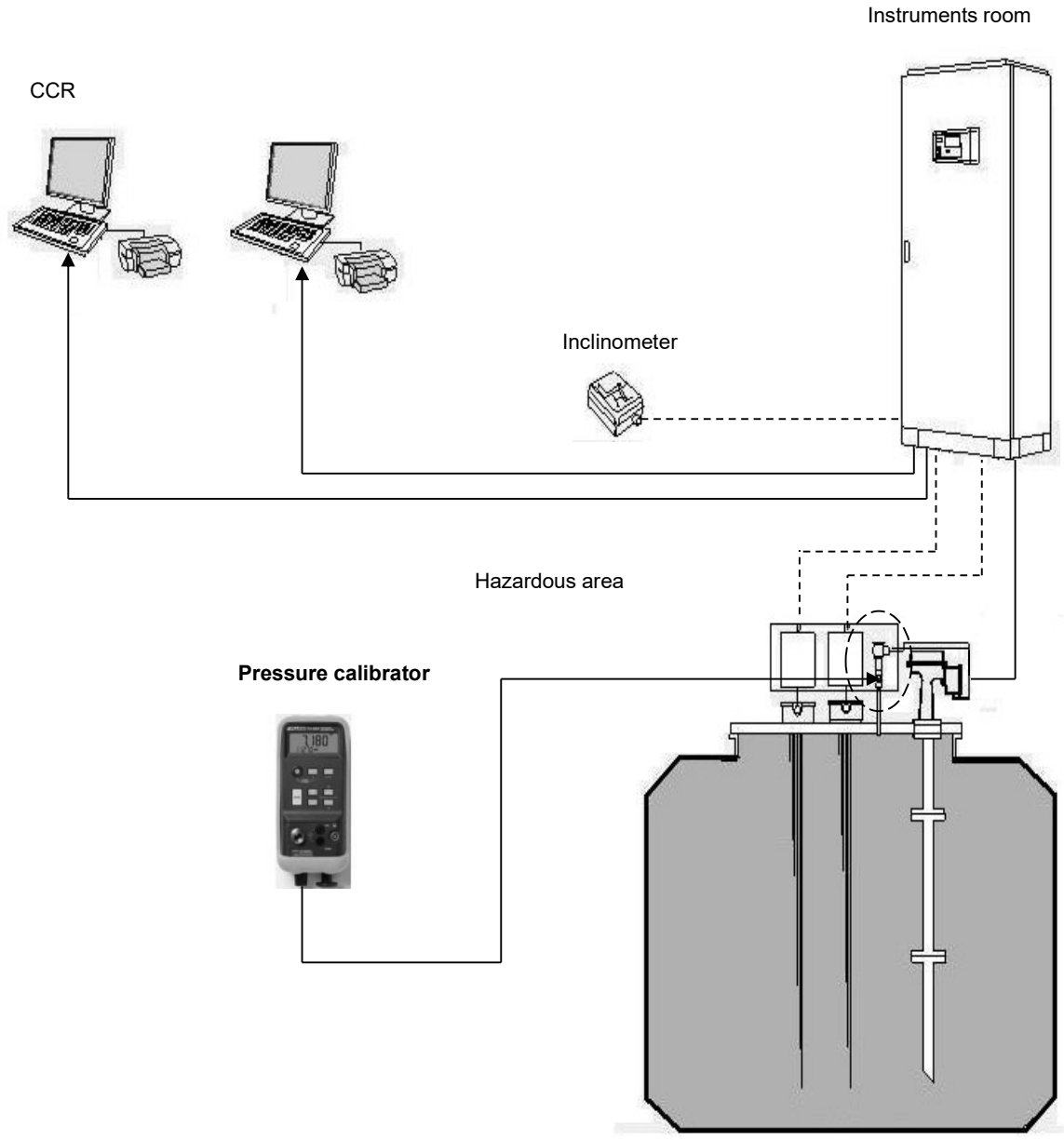
Sensor position	Serial No.	Offset value (ºC)	Input Temp (ºC)	Simulated Temp (º C)	Display	
					CCR (ºC)	Error (ºC)
T5 (TOP)	7711	0.14	-165.00	-164.86	-164.82	0.04
			-100.00	-99.86	-99.84	0.02
			0.00	0.14	0.34	0.20
T4 (75%)	7719	0.15	-165.00	-164.85	-164.81	0.04
			-100.00	-99.85	-99.83	0.02
			0.00	0.15	0.31	0.16
T3 (50%)	7727	0.15	-165.00	-164.85	-164.85	0.00
			-100.00	-99.85	-99.83	0.02
			0.00	0.15	0.31	0.16
T2 (25%)	7735	0.14	-165.00	-164.86	-164.86	0.00
			-100.00	-99.86	-99.88	0.02
			0.00	0.14	0.30	0.16
T1 (BTM)	7743	0.16	-165.00	-164.84	-164.87	0.03
			-100.00	-99.84	-99.86	0.02
			0.00	0.16	0.28	0.12
Maximum error (ºC)			**-165.00**		**0.04**	
			-100.00		**0.02**	
			0.00		**0.20**	

(3) ACCURACY TEST OF PRESSURE MEASURING SYSTEM

1. Purpose : Verify accuracy of pressure gauge and processing chain.

2. Procedure
- Connect pressure calibrator to the pressure gauge.
- Inject pressure 800 mbar, 1100 mbar, 1400 mbar into the pressure gauge.
- Compare display to the simulated pressure.

3. Acceptance criteria : +/- 0.5 % of Full span (+/- 3 mbarA)



PRESSURE MEASURING SYSTEM

All unit in mbarA

Tank No.	Serial No.	Input pressure	Display	
			CCR	Error
1A	134367	800	800	0
		1100	1099	1
		1400	1400	0
		1400	1400	0
		1100	1100	0
		800	801	1
1B	160941	800	802	2
		1100	1101	1
		1400	1401	1
		1400	1402	2
		1100	1100	0
		800	800	0
2A	134227	800	800	0
		1100	1100	0
		1400	1400	0
		1400	1400	0
		1100	1100	0
		800	801	1
2B	135748	800	801	1
		1100	1098	2
		1400	1398	2
		1400	1398	2
		1100	1099	1
		800	800	0
3A	134371	800	800	0
		1100	1099	1
		1400	1400	0
		1400	1399	1
		1100	1099	1
		800	800	0
3B	134372	800	799	1
		1100	1098	2
		1400	1398	2
		1400	1398	2
		1100	1099	1
		800	799	1
4A	134225	800	801	1
		1100	1100	0
		1400	1401	1
		1400	1400	0
		1100	1100	0
		800	799	1
4B	134382	800	801	1
		1100	1101	1
		1400	1400	0
		1400	1400	0
		1100	1101	1
		800	801	1
Maximum error (+/- 0.5 % or +/- 3 mbarA)		**800**	**2**	0.33%
		1100	**2**	0.33%
		1400	**2**	0.33%

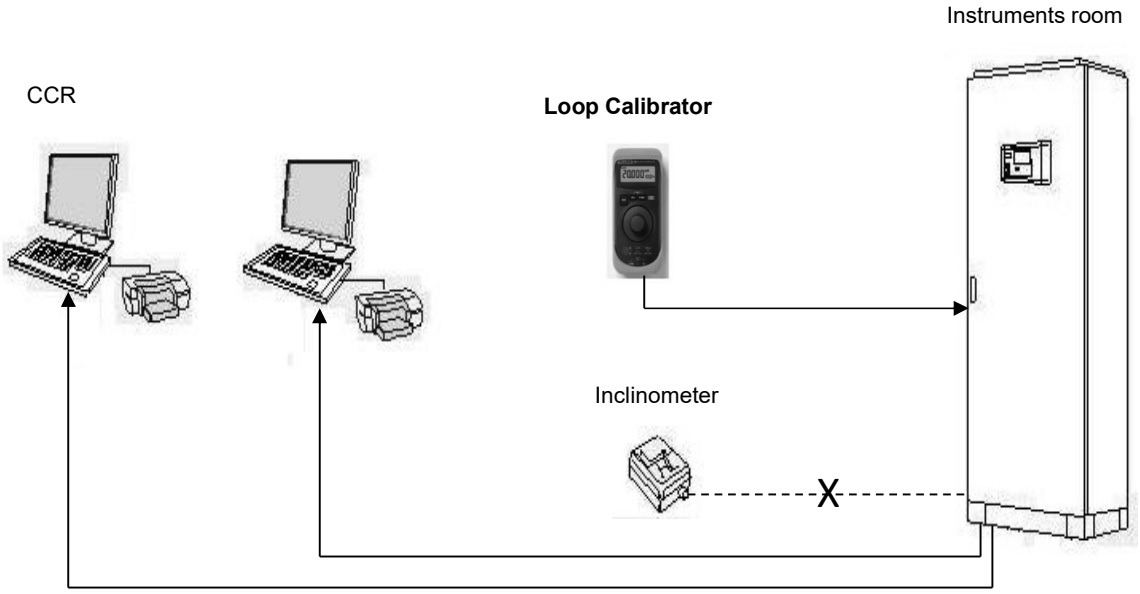
Remark: Pressure Sensor 1B replace with sn 160941 instead of sn 134380

(4) ACCURACY TEST OF TRIM & LIST MEASURING SYSTEM

1. Purpose : Verify trim & list input channel and processing chain.

2. Procedure
- Disconnect the cable from trim & list inclinometer at the CTS cabinet.
- Connect the loop calibrator to the trim & list terminal in the cabinet.
- Simulate the trim to input current (4 ~ 20 mA) from loop calibrator.
- Simulate the list to input current (4 ~ 20 mA) from loop calibrator.
- Compare indicated trim & list with the calculated.

3. Acceptance criteria : +/- 0.5 % of Full span



TRIM & LIST MEASURING SYSTEM

<Trim indicator system>

Simulated value		Expected Trim		Display		Error	
(mA)		(Meter)		(Meter)		(Meter)	(%)
4	mA	9.71	B/H	9.71	B/H	0.00	0.00
8	mA	4.85	B/H	4.86	B/H	0.01	0.05
12	mA	0.00	E/K	0.01	B/H	0.01	0.05
16	mA	4.85	B/S	4.84	B/S	-0.01	-0.05
20	mA	9.71	B/S	9.70	B/S	-0.01	-0.05
Maximum error				**Meter**		**0.01**	
				% FS		**0.05**	

Range : 9.71 B/S to 9.71 B/H LBP (m): 278

Note) B/S : By stern
E/K : Even Keel
B/H : By head

<List indicator system>

Simulated value		Expected Trim		Display		Error	
(mA)		(Degree)		(Degree)		(Degree)	(%)
4	mA	5.00	P	5.00	P	0.00	0.00
8	mA	2.50	P	2.50	P	0.00	0.00
12	mA	0.00	Upright	0.01	P	0.01	0.10
16	mA	2.50	S	2.49	S	-0.01	-0.10
20	mA	5.00	S	4.99	S	-0.01	-0.10
Maximum error				**Degree**		**0.01**	
				% FS		**0.10**	

Range : -5 Deg to +5 Deg

Note) P : To Port
S : To starboard

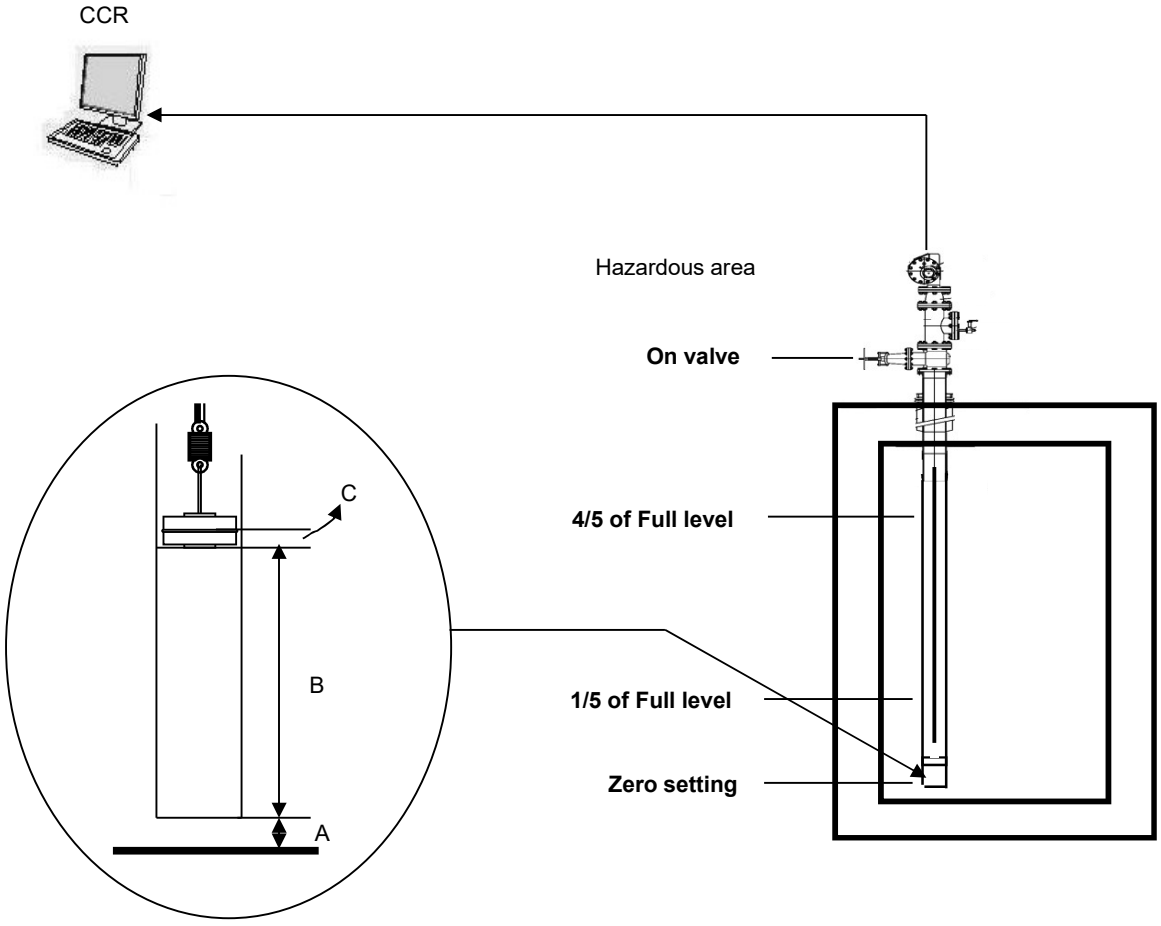
(5) ACCURACY TEST OF FLOAT TYPE LEVEL GAUGE

1. Purpose : Verify accuracy of float level gauge by manual measurement.

2. Procedure
- Measure pedestal height of float gauge pipe in tank in order to set zero.
- Take the float up to 20% and 80% of tank height.
- Measure height of float by tape from tank top.
- Compare display with local reading and tape measurement.
- Measurement will be repeated 3 times for each level.
- Place float on the vapor-cut valve, the indication shall be recorded.
- Place float at the maximum position (Stowed position), the indication shall be recorded.

3. Seal : Gauge head of each float gauge shall be sealed by SGS inspectors.

4. Acceptance criteria : +/- 7.5 mm



All unit in mm.

Tank No.			1		2	
Serial No.			MG2142-01		MG2142-02	
Tank temperature (ºC)			28 ºC		28 ºC	
<Zero setting>						
A (Pedestal height)			65		64	
B (Crossbar height)			0		0	
C (Immersion depth)			71		71	
H (A+B+C)			136		135	
Reading		L	136		135	
		R	134		134	
Error		L	0		0	
		R	2		1	
<Accuracy test>						
	Readings		Counter	Measured Corrected	Counter	Measured Corrected
20% Height 5400mm	1st	L	5400	5401	5400	5402
		R	5400	5398	5400	5399
	2nd	L	5400	5403	5400	5402
		R	5400	5398	5400	5399
	3rd	L	5400	5401	5400	5402
		R	5400	5398	5400	5399
	Max.Error	L	3		2	
		R	2		1	
80% Height 21700mm	1st	L	21700	21705	21700	21704
		R	21700	21698	21700	21699
	2nd	L	21700	21704	21700	21704
		R	21700	21698	21700	21699
	3rd	L	21700	21704	21700	21703
		R	21700	21698	21700	21699
	Max.Error	L	5		4	
		R	2		1	
Float on valve		L	30870		30857	
		R	30867		30858	
Float on stow position		L	30984		30968	
		R	30983		30968	

Maximum Error	**L**	**5.0 mm**	**4.0 mm**
	R	**2.0 mm**	**1.0 mm**

Seal No.	00775	00270

Note)
L : Local display
R : Remote display (CCR)

All unit in mm.

Tank No.		**3**		**4**	
Serial No.		MG2142-03		MG2142-04	
Tank temperature (ºC)		28 ºC		28 ºC	
<Zero setting>					
A (Pedestal height)		64		65	
B (Crossbar height)		0		0	
C (Immersion depth)		71		71	
H (A+B+C)		135		136	
Reading	L	135		136	
	R	135		135	
Error	L	0		0	
	R	0		0	
<Accuracy test>					
	Readings		Counter / Measured Corrected		Counter / Measured Corrected
20% Height 5400mm	1st	L	5400 / 5402		5400 / 5399
		R	5400 / 5400		5400 / 5398
	2nd	L	5400 / 5401		5400 / 5399
		R	5400 / 5400		5400 / 5398
	3rd	L	5400 / 5402		5400 / 5399
		R	5400 / 5400		5400 / 5398
	Max.Error	L	2		1
		R	0		2
80% Height 21700mm	1st	L	21700 / 21702		21700 / 21700
		R	21700 / 21699		21700 / 21699
	2nd	L	21700 / 21703		21700 / 21700
		R	21700 / 21699		21700 / 21698
	3rd	L	21700 / 21704		21700 / 21701
		R	21700 / 21699		21700 / 21699
	Max.Error	L	4		1
		R	1		2
Float on valve		L	30874		30869
		R	30874		30869

Float on stow position	L	30984	30980
	R	30985	30978

Maximum Error	**L**	**4.0 mm**	**1.0 mm**
	R	**1.0 mm**	**2.0 mm**

Seal No.	00251	00840

Note)
L : Local display
R : Remote display (CCR)

3. CERTIFICATES OF USED INSTRUMENTS AT TEST

(1) Resistance box for temperature simulation

(2) Pressure calibrator for pressure simulation

(3) Loop calibrator for trim & list simulation

(4) Tape for float type level gauge verification

KONGSBERG

Certificate of calibration

Equipment : PT-100 Simulator 4 wire.
Manufacturer : Kongsberg Maritime AS, Lade
Type : **WM-27**
Serial No. : 103
Alt.ID. : 33-2044
Item No: 2044
The calibration is based on equipment that is calibrated at planned intervals at an accredited testing laboratory.

Equipment used for the calibration

Manufacturer	Type	Serial no.	Reg. no.
Agilent	3458A	MY45053521	9-2122

Calibration data:

Simulert verdi *imulated value*	Beskrivelse *Description*	Nedre grenseverdi *Lower limit value*	Nom. verdi *Nom. Value*	Øvre grenseverdi *Upper Limit value*	Resultat *Results*	Status *Status*	Error (% of spec.)
-130°C	Pt100 4-wire	47.988	48.004	48.020	**48,005**	Pass	6
20°C	Pt100 4-wire	107.779	107.794	107.808	**107,804**	Pass	67
0°C	Pt100 4-wire	99.985	100.000	100.014	**100,005**	Pass	34
-20°C	Pt100 4-wire	92.145	92.160	92.175	**92,166**	Pass	39
-40°C	Pt100 4-wire	84.256	84.271	84.286	**84,274**	Pass	22
-48°C	Pt100 4-wire	81.085	81.100	81.115	**81,106**	Pass	41
-50°C	Pt100 4-wire	80.291	80.306	80.321	**80,309**	Pass	23
-100°C	Pt100 4-wire	60.241	60.256	60.271	**60,260**	Pass	23
-145°C	Pt100 4-wire	41.787	41.803	41.819	**41,806**	Pass	21
-160°C	Pt100 4-wire	35.528	35.543	35.559	**35,543**	Pass	2
-165°C	Pt100 4-wire	33.427	33.443	33.459	**33,439**	Pass	-27

Anmerkninger:

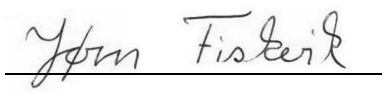
Nøyaktighet innenfor ett års kalibrering: ± 0,04% ved 23 ºC omgivelsestemperatur.
Temperaturkoeffisient i området -20 til 40 °C: < 5 ppm/°C.
Nominelle motstandsverdier for Pt100 simulering er referert til IEC 60751 Edition 2, 2008.
For grenseverdiene i tabellene er medregnet vår måleusikkerhet.
Målestrøm: 1 mA.

REMARKS:

Accuracy within one year calibration cycle: ± 0.04 °C at 23 °C ambient temperature.
Temperature coefficient within range -20 to 40 °C: <5 ppm/°C.
Nominal resistor values for Pt100 simulation are referred to IEC 60751 Edition 2, 2008.
Limit values in the table includes our measuring uncertainty
Measuring current: 1 mA.

Calibrated: 2019.09.04

Calibrated by:



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Foretaksregisteret NO 979 750 730 MVA Bank account 7058 06 84023

Kongsberg Maritime

KONGSBERG

Certificate of calibration

Equipment : PT-100 Simulator 4 wire.
Manufacturer : Kongsberg Maritime AS, Lade
Type : **WM-27**
Serial No. : 104
Alt.ID. : 33-2044
Item No: 2044
The calibration is based on equipment that is calibrated at planned intervals at an accredited testing laboratory.

Equipment used for the calibration

Manufacturer	Type	Serial no.	Reg. no.
Agilent	3458A	MY45053521	9-2122

Calibration data:

Simulert verdi *imulated value*	Beskrivelse *Description*	Nedre grenseverdi *Lower limit value*	Nom. verdi *Nom. Value*	Øvre grenseverdi *Upper Limit value*	Resultat *Results*	Status *Status*	Error (% of spec.)
-130°C	Pt100 4-wire	47.988	48.004	48.020	**48,008**	Pass	26
20°C	Pt100 4-wire	107.779	107.794	107.808	**107,801**	Pass	46
0°C	Pt100 4-wire	99.985	100.000	100.014	**100,004**	Pass	26
-20°C	Pt100 4-wire	92.145	92.160	92.175	**92,169**	Pass	58
-40°C	Pt100 4-wire	84.256	84.271	84.286	**84,276**	Pass	32
-48°C	Pt100 4-wire	81.085	81.100	81.115	**81,107**	Pass	46
-50°C	Pt100 4-wire	80.291	80.306	80.321	**80,309**	Pass	22
-100°C	Pt100 4-wire	60.241	60.256	60.271	**60,264**	Pass	56
-145°C	Pt100 4-wire	41.787	41.803	41.819	**41,805**	Pass	13
-160°C	Pt100 4-wire	35.528	35.543	35.559	**35,546**	Pass	22
-165°C	Pt100 4-wire	33.427	33.443	33.459	**33,443**	Pass	3

Anmerkninger:

Nøyaktighet innenfor ett års kalibrering: ± 0,04% ved 23 ºC omgivelsestemperatur.
Temperaturkoeffisient i området -20 til 40 °C: < 5 ppm/°C.
Nominelle motstandsverdier for Pt100 simulering er referert til IEC 60751 Edition 2, 2008.
For grenseverdiene i tabellene er medregnet vår måleusikkerhet.
Målestrøm: 1 mA.

REMARKS:

Accuracy within one year calibration cycle: ± 0.04 °C at 23 °C ambient temperature.
Temperature coefficient within range -20 to 40 °C: <5 ppm/°C.
Nominal resistor values for Pt100 simulation are referred to IEC 60751 Edition 2, 2008.
Limit values in the table includes our measuring uncertainty
Measuring current: 1 mA.

Calibrated: 2019.09.04

Calibrated by:

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Foretaksregisteret NO 979 750 730 MVA Bank account 7058 06 84023

KONGSBERG

Certificate of calibration

Equipment : PT-100 Simulator 4 wire.
Manufacturer : Kongsberg Maritime AS, Lade
Type : **WM-27**
Serial No. : 105
Alt.ID. : 33-2044
Item No: 2044
The calibration is based on equipment that is calibrated at planned intervals at an accredited testing laboratory.

Equipment used for the calibration

Manufacturer	Type	Serial no.	Reg. no.
Agilent	3458A	MY45053521	9-2122

Calibration data:

Simulert verdi *imulated value*	Beskrivelse *Description*	Nedre grenseverdi *Lower limit value*	Nom. verdi *Nom. Value*	Øvre grenseverdi *Upper Limit value*	Resultat *Results*	Status *Status*	Error (% of spec.)
-130°C	Pt100 4-wire	47.988	48.004	48.020	**48,008**	Pass	24
20°C	Pt100 4-wire	107.779	107.794	107.808	**107,801**	Pass	44
0°C	Pt100 4-wire	99.985	100.000	100.014	**100,005**	Pass	31
-20°C	Pt100 4-wire	92.145	92.160	92.175	**92,167**	Pass	45
-40°C	Pt100 4-wire	84.256	84.271	84.286	**84,275**	Pass	25
-48°C	Pt100 4-wire	81.085	81.100	81.115	**81,105**	Pass	34
-50°C	Pt100 4-wire	80.291	80.306	80.321	**80,311**	Pass	31
-100°C	Pt100 4-wire	60.241	60.256	60.271	**60,260**	Pass	25
-145°C	Pt100 4-wire	41.787	41.803	41.819	**41,806**	Pass	19
-160°C	Pt100 4-wire	35.528	35.543	35.559	**35,545**	Pass	11
-165°C	Pt100 4-wire	33.427	33.443	33.459	**33,444**	Pass	6

Anmerkninger:

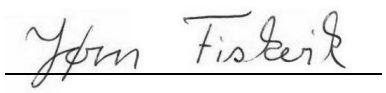
Nøyaktighet innenfor ett års kalibrering: ± 0,04% ved 23 ºC omgivelsestemperatur.
Temperaturkoeffisient i området -20 til 40 °C: < 5 ppm/°C.
Nominelle motstandsverdier for Pt100 simulering er referert til IEC 60751 Edition 2, 2008.
For grenseverdiene i tabellene er medregnet vår måleusikkerhet.
Målestrøm: 1 mA.

REMARKS:

Accuracy within one year calibration cycle: ± 0.04 °C at 23 °C ambient temperature.
Temperature coefficient within range -20 to 40 °C: <5 ppm/°C.
Nominal resistor values for Pt100 simulation are referred to IEC 60751 Edition 2, 2008.
Limit values in the table includes our measuring uncertainty
Measuring current: 1 mA.

Calibrated: 2019.09.04

Calibrated by:



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Foretaksregisteret NO 979 750 730 MVA Bank account 7058 06 84023

KONGSBERG

Certificate of calibration

Equipment : PT-100 Simulator 4 wire.
Manufacturer : Kongsberg Maritime AS, Lade
Type : **WM-27**
Serial No. : 106
Alt.ID. : 33-2045
Item No: 2045
The calibration is based on equipment that is calibrated at planned intervals at an accredited testing laboratory.

Equipment used for the calibration

Manufacturer	Type	Serial no.	Reg. no.
Agilent	3458A	MY45053521	9-2122

Calibration data:

Simulert verdi *imulated value*	Beskrivelse *Description*	Nedre grenseverdi *Lower limit value*	Nom. verdi *Nom. Value*	Øvre grenseverdi *Upper Limit value*	Resultat *Results*	Status *Status*	Error (% of spec.)
-130°C	Pt100 4-wire	47.988	48.004	48.020	**48,008**	Pass	25
20°C	Pt100 4-wire	107.779	107.794	107.808	**107,801**	Pass	46
0°C	Pt100 4-wire	99.985	100.000	100.014	**100,004**	Pass	27
-20°C	Pt100 4-wire	92.145	92.160	92.175	**92,168**	Pass	50
-40°C	Pt100 4-wire	84.256	84.271	84.286	**84,274**	Pass	21
-48°C	Pt100 4-wire	81.085	81.100	81.115	**81,106**	Pass	41
-50°C	Pt100 4-wire	80.291	80.306	80.321	**80,311**	Pass	34
-100°C	Pt100 4-wire	60.241	60.256	60.271	**60,261**	Pass	30
-145°C	Pt100 4-wire	41.787	41.803	41.819	**41,805**	Pass	13
-160°C	Pt100 4-wire	35.528	35.543	35.559	**35,545**	Pass	12
-165°C	Pt100 4-wire	33.427	33.443	33.459	**33,446**	Pass	16

Anmerkninger:

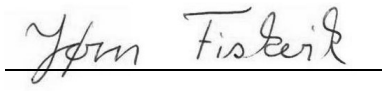
Nøyaktighet innenfor ett års kalibrering: ± 0,04% ved 23 ºC omgivelsestemperatur.
Temperaturkoeffisient i området -20 til 40 °C: < 5 ppm/°C.
Nominelle motstandsverdier for Pt100 simulering er referert til IEC 60751 Edition 2, 2008.
For grenseverdiene i tabellene er medregnet vår måleusikkerhet.
Målestrøm: 1 mA.

REMARKS:

Accuracy within one year calibration cycle: ± 0.04 °C at 23 °C ambient temperature.
Temperature coefficient within range -20 to 40 °C: <5 ppm/°C.
Nominal resistor values for Pt100 simulation are referred to IEC 60751 Edition 2, 2008.
Limit values in the table includes our measuring uncertainty
Measuring current: 1 mA.

Calibrated: 2019.09.04

Calibrated by:



KONGSBERG MARITIME AS
Postal address: P.O.Box 2434 NO-7005 Trondheim, Norway
Delivery address: Skonnertvegen. 1, 7053 Ranheim Norway
Invoice address: P.O.Box 483, N-3601 Kongsberg Norway
Invoice mail: km.finance@km.kongsberg.com
Phone +47 73 58 10 00 Fax +47 73 58 10 01 www.kongsberg.com
Foretaksregisteret NO 979 750 730 MVA Bank account 7058 06 84023

Kongsberg Maritime

KONGSBERG

Certificate of calibration

Equipment : PT-100 Simulator 4 wire.
Manufacturer : Kongsberg Maritime AS, Lade
Type : **WM-27**
Serial No. : 107
Alt.ID. : 33-2045
Item No: 2045
The calibration is based on equipment that is calibrated at planned intervals at an accredited testing laboratory.

Equipment used for the calibration

Manufacturer	Type	Serial no.	Reg. no.
Agilent	3458A	MY45053521	9-2122

Calibration data:

Simulert verdi *imulated value*	Beskrivelse *Description*	Nedre grenseverdi *Lower limit value*	Nom. verdi *Nom. Value*	Øvre grenseverdi *Upper Limit value*	Resultat *Results*	Status *Status*	Error (% of spec.)
-130°C	Pt100 4-wire	47.988	48.004	48.020	**48,008**	Pass	25
20°C	Pt100 4-wire	107.779	107.794	107.808	**107,801**	Pass	48
0°C	Pt100 4-wire	99.985	100.000	100.014	**100,004**	Pass	28
-20°C	Pt100 4-wire	92.145	92.160	92.175	**92,168**	Pass	52
-40°C	Pt100 4-wire	84.256	84.271	84.286	**84,274**	Pass	22
-48°C	Pt100 4-wire	81.085	81.100	81.115	**81,105**	Pass	31
-50°C	Pt100 4-wire	80.291	80.306	80.321	**80,310**	Pass	26
-100°C	Pt100 4-wire	60.241	60.256	60.271	**60,257**	Pass	9
-145°C	Pt100 4-wire	41.787	41.803	41.819	**41,807**	Pass	25
-160°C	Pt100 4-wire	35.528	35.543	35.559	**35,546**	Pass	20
-165°C	Pt100 4-wire	33.427	33.443	33.459	**33,448**	Pass	32

Anmerkninger:

Nøyaktighet innenfor ett års kalibrering: ± 0,04% ved 23 ºC omgivelsestemperatur.
Temperaturkoeffisient i området -20 til 40 °C: < 5 ppm/°C.
Nominelle motstandsverdier for Pt100 simulering er referert til IEC 60751 Edition 2, 2008.
For grenseverdiene i tabellene er medregnet vår måleusikkerhet.
Målestrøm: 1 mA.

REMARKS:

Accuracy within one year calibration cycle: ± 0.04 °C at 23 °C ambient temperature.
Temperature coefficient within range -20 to 40 °C: <5 ppm/°C.
Nominal resistor values for Pt100 simulation are referred to IEC 60751 Edition 2, 2008.
Limit values in the table includes our measuring uncertainty
Measuring current: 1 mA.

Calibrated: 2019.09.04

Calibrated by:

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Foretaksregisteret NO 979 750 730 MVA Bank account 7058 06 84023

Kongsberg Maritime

KONGSBERG

Certificate of calibration

Equipment : PT-100 Simulator 4 wire.
Manufacturer : Kongsberg Maritime AS, Lade
Type : **WM-27**
Serial No. : 108
Alt.ID. : 33-2045
Item No: 2045
The calibration is based on equipment that is calibrated at planned intervals at an accredited testing laboratory.

Equipment used for the calibration

Manufacturer	Type	Serial no.	Reg. no.
Agilent	3458A	MY45053521	9-2122

Calibration data:

Simulert verdi *imulated value*	Beskrivelse *Description*	Nedre grenseverdi *Lower limit value*	Nom. verdi *Nom. Value*	Øvre grenseverdi *Upper Limit value*	Resultat *Results*	Status *Status*	Error (% of spec.)
-130°C	Pt100 4-wire	47.988	48.004	48.020	**48,007**	Pass	21
20°C	Pt100 4-wire	107.779	107.794	107.808	**107,800**	Pass	43
0°C	Pt100 4-wire	99.985	100.000	100.014	**100,004**	Pass	25
-20°C	Pt100 4-wire	92.145	92.160	92.175	**92,165**	Pass	33
-40°C	Pt100 4-wire	84.256	84.271	84.286	**84,274**	Pass	19
-48°C	Pt100 4-wire	81.085	81.100	81.115	**81,106**	Pass	40
-50°C	Pt100 4-wire	80.291	80.306	80.321	**80,309**	Pass	20
-100°C	Pt100 4-wire	60.241	60.256	60.271	**60,259**	Pass	17
-145°C	Pt100 4-wire	41.787	41.803	41.819	**41,806**	Pass	19
-160°C	Pt100 4-wire	35.528	35.543	35.559	**35,544**	Pass	9
-165°C	Pt100 4-wire	33.427	33.443	33.459	**33,441**	Pass	-15

Anmerkninger:

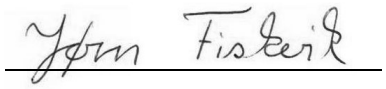
Nøyaktighet innenfor ett års kalibrering: ± 0,04% ved 23 ºC omgivelsestemperatur.
Temperaturkoeffisient i området -20 til 40 °C: < 5 ppm/°C.
Nominelle motstandsverdier for Pt100 simulering er referert til IEC 60751 Edition 2, 2008.
For grenseverdiene i tabellene er medregnet vår måleusikkerhet.
Målestrøm: 1 mA.

REMARKS:

Accuracy within one year calibration cycle: ± 0.04 °C at 23 °C ambient temperature.
Temperature coefficient within range -20 to 40 °C: <5 ppm/°C.
Nominal resistor values for Pt100 simulation are referred to IEC 60751 Edition 2, 2008.
Limit values in the table includes our measuring uncertainty
Measuring current: 1 mA.

Calibrated: 2019.09.04

Calibrated by:



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Kongsberg Maritime

KONGSBERG

Certificate of calibration

Equipment :	Fluke Multimeter
Manufacturer :	Fluke Corporation
Type :	700PA4Ex
Serial No. :	15205702
Alt. Id. :	9-1902
Item No.:	1902

This instrument is calibrated and tested in accordance with calibration specifications by Fluke Corporation. Equipment used for the calibration is calibrated at regular intervals at an accredited testing laboratory. Calibrations of all the units are traceable to the Norwegian National Standards with correlation to other European National Standards.

The environment where this instrument was calibrated is maintained within the operating specifications of the instrument and the standards.

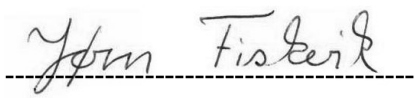
Equipment used for the calibration

Manufacturer	Type	Serial No.	Reg. No.
Ruska	7252	62993	9-338
Fluke	718Ex	1531217	9-1901

Room temperature:	24,1 ºC
Humidity:	32,5 %

Calibrated : 2019.09.03

Calibrated by :



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KONGSBERG

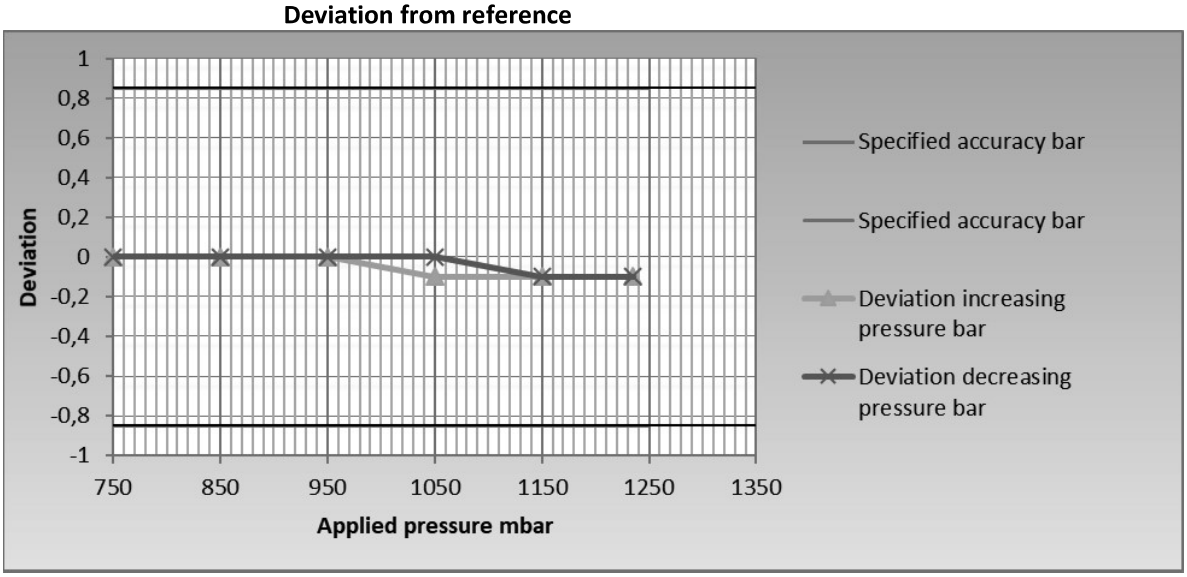
Certificate of calibration

700PA4Ex Pressure Verification

Specified accurracy:	mbara		% of full scale
Lowest pressure:	750		0,07
To and from Pressure	1240		0,07

Result of calibration, pressure measurements.

Applied pressure bara	Reading increasing mbara	Reading decreasing mbara	Status
0,750	750,0	750,0	Pass
0,850	850,0	850,0	Pass
0,950	950,0	950,0	Pass
1,050	1049,9	1050,0	Pass
1,150	1149,9	1149,9	Pass
1,235	1234,9	1234,9	Pass



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Kongsberg Maritime

KONGSBERG

Certificate of calibration

Equipment :	Fluke Multimeter
Manufacturer :	Fluke Corporation
Type :	718Ex 100G
Serial No. :	4512385
Alt. Id. :	9-2204
Item No.:	2204

This instrument is calibrated and tested in accordance with calibration specifications by Fluke Corporation. Equipment used for the calibration is calibrated at regular intervals at an accredited testing laboratory. Calibrations of all the units are traceable to the Norwegian National Standards with correlation to other European National Standards.

The environment where this instrument was calibrated is maintained within the operating specifications of the instrument and the standards.

Equipment used for the calibration

Manufacturer	**Type**	**Serial No.**	**Reg. No.**
Fluke	5500A	1497001	9-1880
Agilent	3458A	MY45053521	9-2122
Ruska	7252	62993	9-338

Room temperature:	24,1 ºC
Humidity:	32,5 %

Calibrated : 2019.09.03

Calibrated by :

John Fisterik

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KONGSBERG

Certificate of calibration

mA Measure Verification

Range	Reading Agilent 3458A	Reading UUT	Specification limits min	Specification limits max	Error (% of spec.)	Status
24mA	4,000022	**4,000**	3,997	4,003	-1	Pass
24mA	12,00032	**12,001**	11,996	12,004	-17	Pass
24mA	24,00107	**24,001**	23,993	24,007	1	Pass

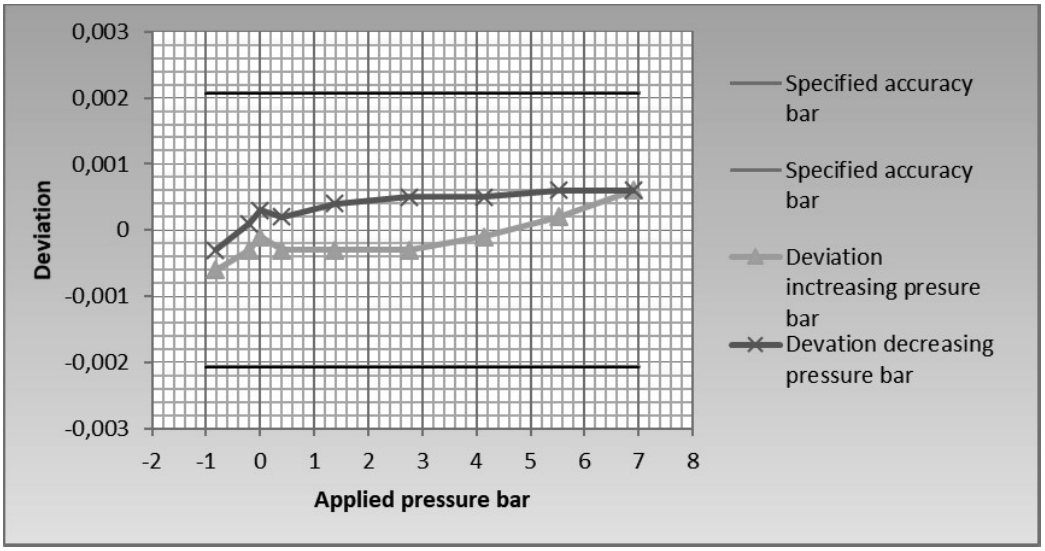
718Ex Pressure Verification

Specified accurracy:	bar		% of full scale
Lowest pressure:	-1,0		0,05
To and from Pressure	6,9		0,05

Result of calibration, pressure measurements.

Applied pressure bar	Reading increasing bar	Reading decreasing bar	Status
-0,8300	**-0,8306**	**-0,8303**	Pass
-0,2000	**-0,2003**	**-0,1999**	Pass
0,0000	**-0,0001**	**0,0003**	Pass
0,4000	**0,3997**	**0,4002**	Pass
1,3800	**1,3797**	**1,3804**	Pass
2,7600	**2,7597**	**2,7605**	Pass
4,1400	**4,1399**	**4,1405**	Pass
5,5200	**5,5202**	**5,5206**	Pass
6,9000	**6,9006**	**6,9006**	Pass

Deviation from reference



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Foretaksregisteret NO 979 750 730 MVA Bank account 7058 06 84023

Kongsberg Maritime

KONGSBERG

Certificate of calibration

Equipment : Fluke Calibrator
Manufacturer : Fluke Corporation
Type : 707Ex
Serial No. : 9632119
Alt. ID. : 7-56
Item No.: 341

This instrument is calibrated and tested in accordance with calibration specifications by Fluke Corporation. Equipment used for the calibration is calibrated at regular intervals at an accredited testing laboratory. Calibrations of all the units are traceable to the Norwegian National Standards with correlation to other European National Standards.

The environment where this instrument was calibrated is maintained within the operating specifications of the instrument and the standards.

Equipment used for the calibration

Manufacturer	Type	Serial No.	Reg. No.
Agilent (HP)	3458A	MY45053521	9-2122
Fluke	5500A	1497001	9-1880

Calibration counter: 0003
Room temperature: 22,8°C
Remarks: None.

Calibration data

Test No.	707Ex Output	Mode	HP3458A Min	HP3458A Max	Result	Error (% of spec)
1	4.000mA	mA Source	3.9974 mA	4.0026 mA	**3,9996**	-15
2	12.000mA	mA Source	11.9962 mA	12.0038 mA	**11,9992**	-21
3	24.000mA	mA Source	23.9944 mA	24.0056 mA	**23,9986**	-25
Test No.	**5500A Output**	**Mode**	**707 Min**	**707 Max**	**Result**	
4	4.000 mA	mA Measure	3.997 mA	4.003 mA	**4,000**	0
5	12.000 mA	mA Measure	11.996 mA	12.004 mA	**12,001**	25
6	24.000 mA	mA Measure	23.994 mA	24.006 mA	**24,001**	17
Test No.	**5500A Output**	**Mode**	**707 Min**	**707 Max**	**Result**	
7	0.000 V	Volt Measure	-0.002 V	0.002 V	**0,000**	0
8	14.000 V	Volt Measure	13.995 V	14.005 V	**13,999**	-20
9	28.000 V	Volt Measure	27.993 V	28.007 V	**27,999**	-14

Calibrated : 2019.09.03

Calibrated by :

John Fisterik

KONGSBERG MARITIME AS
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证书编号:CL017-190329029
Certificate No.

NBJL

NINGBO INSTITUTE OF MEASUREMENT AND TESTING

宁波市计量测试研究院

Ningbo Institute of Measurement and Testing

校准证书

Calibration Certificate

委托方 Customer	通标标准技术服务有限公司宁波分公司
委托方地址 Address of customer	宁波市高新区凌云路 1177 号
器具名称 Name of instrument	钢卷尺
制造厂 Manufacturer	天津市雄狮工量具有限公司
型号/规格 Type/Specification	50m
器具准确度 Instrument accuracy	/
器具编号 No. of instrument	OGCMIG27

(校准专用章)
(Stamp)

批准人 Approved by 朱招南

核验员 Checked by 夏鑫

校准员 Calibrated by 汪伟走

校准日期 Date for calibrated 2019 年 year 03 月 Month 29 日 Day

地址(Address):宁波国家高新区江南路 1588 号 E 座 邮编(Post Code):315048
电话(Tel):0574-87835065 传真(Fax):0574-87880204 网址(Net add):www.nbjlw.com

国家法定计量检定机构计量授权证书号：（浙）法计（2018）33002 号
The number of the Certificate of Metrological Authorization to The Legal Metrological Verification Institution is No.(2018)33002
本实验室管理体系符合 ISO/IEC 17025 要求
The management of laboratory is in accordance with ISO/IEC 17025

本次校准所依据的技术规范（代号、名称）：
Reference documents for the calibration (code、name)

JJG 4-2015 钢卷尺检定规程

本次校准所使用的主要计量标准器具：

名称/型号 Name/Model	编号 Number	证书编号/有效期限 Certificate No./Due date	测量范围/准确度 Measuring range/accuracy
标准钢卷尺/5m	120008	CDjx2018-3636 2019-9-24	（0~5）m MPE：±（0.03+0.03L）mm

以上计量标准器具的量值溯源至国家基准。
Quantity Values of above measurement standards used in this verification are traced to those of the national primary standards in the P.R.China

校准地点及环境条件：
Location and environmental condition for the calibration
地点：宁波市计量测试研究院
Location

温度：20.5 ℃；相对湿度：60 %；其他：/
Ambient temperature Relative humidity Others

本次校准结果的不确定度：U=(0.2~1.0)mm k=2
Measurement Uncertainty

建议再校日期：
Commented Recalibration Date
如果希望在制造商指定的技术指标范围内，或者在技术法规规定的范围内使用本校准结果，
If you hope to use the calibration date complying with specification and regulation,please recalibrate it before the date given out.
则建议在 2020 年 03 月 29 日前进行复校。

校准结果/说明：
Result of certificate and additional explanation
见第 3 页

本证书提供的结果**仅对本次被校的器具有效。**
The data are valid only for the instrument(s)

校准结果/说明（续页）:
Results of certificate and additional explanation (continued page)

张力：49N

校准间隔 (m)	修正值 (mm)
0～10	-0.2
0～20	-0.2
0～30	-0.1
0～40	-0.3
0～50	-0.6

【以下空白】

4. CERTIFICATE OF NEW REPLACED PRESSURE TRANSMITTER

Location of test : **Kongsberg Maritme AS in Trondheim, Norway**

Date : **20 Aug 2019**

Serial No. : **160941**

Replacement : **CT 1B**

Calibration certificate
Pressure sensor

KONGSBERG

Manufacturer:	**Kongsberg Maritime AS**
Address:	**Skonnertvegen 1, N-7005 Trondheim**
Sensor type:	**GT402E4C0.6L**
Pressure range:	**0,8 to 1,4 Bar Absolute**
Accuracy	**0,9 %FRO in the range -30 to 70°C**
Sensor serial no:	**160941**
Date of calibration:	**2019-08-20**

Deviation table [%FRO] (%FRO = % of Full Range Output)

	Applied pressure [% FRO]					
Temperature	**0,0 %**	**20,0 %**	**40,0 %**	**60,0 %**	**80,0 %**	**100,0 %**
-30°C	-0,10	-0,21	-0,16	-0,21	-0,12	-0,27
0°C	-0,03	-0,06	-0,08	-0,08	-0,10	-0,19
22°C	-0,06	-0,08	-0,06	0,04	-0,08	-0,12
70°C	0,05	0,05	-0,01	-0,05	-0,03	0,11