

經濟部暨所屬機關因公出國人員報告書  
(出國類別：洽公 )

LNG 船計量設備校驗工作  
報告書

服務機關：台灣中油天然氣事業部永安液化天然氣廠

姓名職稱：郭慶輝/儀電工程師

派赴國家：馬來西亞

出國期間：98 年 11 月 1 日至 11 月 4 日

報告日期：99 年 1 月 4 日

經濟部暨所屬機關出國報告提要

出國報告名稱：LNG 船計量設備校驗工作

頁數 40 含附件：是否

出國計畫主辦機關/聯絡人/電話

台灣中油永安液化天然氣廠/沈佑雄/07-6911131-231

出國人員姓名/服務機關/單位/職稱/電話

郭慶輝/台灣中油天然氣事業部永安液化天然氣廠/儀電組/儀電工程師/07-6911131-352

出國類別：1 考察2 進修3 研究4 實習5 其他

出國期間：98/11/01~98/11/04

出國地區：馬來西亞

報告日期：99/01/04

分類號/目

關鍵詞：

內容摘要：(二百至三百字)

本公司每年自國外進口大量液化天然氣(LNG)，以供應國內工業及民生用戶所需，來源產地其一為馬來西亞。目前國內僅有本公司永安廠及台中廠二座國內液化天然氣接收站，而永安廠又是作為馬來西亞之 LNG 船之主要卸收站，每艘 LNG 船次之卸收數量，係以船艙計量測系統之卸收前及卸收後之數據資料為依據，因此本套液位量測系統之準確性影響交易雙方之權益及金額甚鉅，對船上相關設備進行校驗及驗證是必要的工作。本次執行校驗工作是由第三獨立檢驗機構日本海事檢定協會(NKKK, NIPPON KAIJI KENTEI KYOKAI)進行，馬方(MLNG, MALAYSIA LNG SDN. BHD.)與本公司雙方皆派員會同參與見證。

此次馬來西亞 PUTERI FIRUS LNG 船於馬來西亞(Johor Bahru) Pasir Gudang 之 MMHE (Malaysia Marine And Heavy Engineering Sdn. Bhd.) shipyard 進行檢修，同時進行相關計量設備之校驗工作，包括：(一) CT-IV 液位量測系統(CAPACITANCE TYPE LEVEL)，(二) CT-IV 溫度量測系統(TEMPERATURE SYSTEM)，(三) CT-IV 壓力量測系統(PRESSURE SYSTEM)，(四) 浮球式液位計(FLOAT LEVEL GAUGE)等，並由日本海事檢定協會以第三公正的獨立檢驗機構代表執行校驗工作。

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## 一、目的

本公司每年自國外進口大量液化天然氣 (LNG)，以供應國內用戶所需，來源產地其一為馬來西亞。目前國內僅有本公司永安廠及台中廠二座國內液化天然氣接收站，而永安廠又是作為馬來西亞之 LNG 船之主要卸收站，每艘 LNG 船次之卸收數量，係以船艙計量測系統之卸收前及卸收後之數據資料為依據，因此該液位量測系統之準確性影響交易雙方之權益及金額甚鉅，對船上相關設備進行校驗及驗證是必要的工作。本次執行校驗工作是由第三獨立檢驗機構日本海事檢定協會(NKKK, NIPPON KAIJI KENTEI KYOKAI)進行，馬方(MLNG, MALAYSIA LNG SDN. BHD.)與本公司雙方皆派員會同參與見證。

此次馬來西亞 PUTERI FIRUS LNG 船於馬來西亞 (Johor Bahru) Pasir Gudang 之 MMHE (Malaysia Marine And Heavy Engineering Sdn. Bhd.) shipyard 進行檢修，同時進行相關計量設備之校驗工作，包括：(一) CT-IV 液位量測系統 (CAPACITANCE TYPE LEVEL)，(二) CT-IV 溫度量測系統 (TEMPERATURE SYSTEM)，(三) CT-IV 壓力量測系統 (PRESSURE SYSTEM)，(四) 浮球式液位計 (FLOAT LEVEL GAUGE) 等，並由日本海事檢定協會以第三公正的獨立檢驗機構代表執行校驗工作。上述各項量測設備之校驗結果及方法(如附件)。

## 二、行程

- 11 月 1 日：啓程前馬來西亞 Pasir Gudang (Johor Bahru)。
- 11 月 2 日：參與相關計量設備之校驗工作。
- 11 月 3 日：相關計量設備之校驗工作及彙整各項測試資料，檢討驗證結果。
- 11 月 4 日：返程回國。

## 三、概述

(一) 參與此次檢測及校驗人員代表如下：

(1) 買方代表

台灣中油股份有限公司天然氣事業部永安廠儀電組  
郭慶輝。

(2) 賣方代表

MALAYSIA LNG SDN. BHD.(MLNG)  
Christy Tan Pei Ching  
Hairulirwan Abu Hassan

(3) 船運公司代表

MISC  
SHAHRUL EFFENDY AHMAD TAJUDIN

(4) 第三獨立檢驗機構代表

NIPPON KAIJI KENTEI KYOKAI (NKKK)  
TEO KIAN HAN

## （二）LNG 船艙計量設備原理

由於 LNG 船承載之物品是超低溫可燃性液化天然氣，其船艙必須密閉，計量時無法以類似原油船自船艙口直接測量液位，用以計算所交付之體積及重量之方式進行。故需採取以 LNG 船於建造時，在船艙所裝設之液位計、溫度計及壓力計等感測器，將所量測到的信號值，同時傳送至船艙計量系統 CT-IV 中的電腦工作站，並參考船身俯仰、傾斜的物理量進行計量運算，最後將結果同時以圖形及數字方式顯示於監視器螢幕，另外並以印表機印出數據，以便做為買賣雙方計算 LNG 之體積數量之依據。

本艘 LNG 船 PUTERI FIRUS 上共計有四個船艙，當船艙裝載 LNG 後，其流體會造成電容式液位感測器之電容值產生增減，以對應液位變化，再參酌溫度及壓力值後，經由電腦進行運算，即可將液位轉換為相對之體積值，並參考船身俯仰、傾斜的物理量後，計算出船艙儲槽內 LNG 之體積。各船艙另設置一浮球式液位計，藉由鋼索導引，浮力使感應元件之上升下降偵測液面高度。

## 四、計量設備校驗工作程序及驗證結果

### （一）CT-IV 液位量測系統（CAPACITANCE TYPE LEVEL）

本套液位量測系統之液位計係採用電容式液位計，其量測原理是船艙內之流以體液位變動時，藉由流體之介電係數改變，使其感測器之電容值產生的變化，進而偵測液面高度，然後變動信號至液位轉換器模組，液位轉換器模組經數位化後送至控制處理器，控制處理器將數位信號轉換成不同刻度範圍及不同工程單位的物理量。本次 PUTERI FIRUS 每個船艙之電容式液位計共由 6 節電容感應器所組成，但因船艙內已清空尚未進料，無法實際量測之液位高度，因此採用原製造商提供之乾式校準（DRY CALIBRATION）方式進行各節電容感應器之校驗（如圖一），其方式如下：

- （1）於船艙計量系統電腦工作站執行乾式校準工作。
- （2）於船艙計量系統之圖控畫貌執行 DRY TEST 功能。
- （3）記錄下於畫貌上所顯示之空槽狀態下之數據。
- （4）執行 DRY TEST，分別以每一節電容式液位計之實際值及 DRY CALIBRATION 預設之組態規劃值，計算每一節電容式液位計之液位數據。
- （5）檢驗並記錄滿槽狀態下之數據，啟動 DRY TEST，分別以模擬之滿刻度數值計算每一節電容式液位計之液位數據。
- （6）經校驗量測 4 個貨艙內電容式液位計的 DRY TEST 校準功能，其校驗結果均於誤差範圍內，符合要求。

CTS		DRY CALIBRATION TEST RESULTS		TANKS INFORMATION
TEMPERATURE IN THE TANK		26	DEG C	TANK # 4
Channel #	Empty channel value (metres)	Full segment length (metres)	Full segment top height (metres)	
Ref	0.000	0.360	0.386	
1	0.000	4.992	5.018	
2	0.000	5.018	10.036	
3	0.000	2.710	12.746	
4	0.000	2.609	15.355	
5	0.000	5.019	20.374	
6	0.000	5.021	25.395	

EXIT

圖一、電容式液位計 DRY CALIBRATION

(二) CT-IV 溫度量測系統 (TEMPERATURE SYSTEM)

由於在計算船艙之 LNG 體積時，需將當時之實際溫度及壓力值補償計算，以便取得經補償後之正確體積值，因此溫度的正確與否，亦會影響其最終計算結果，且其亦設置二套溫度量測系統做為備援。其溫度信號校驗方式如下：

- (1) 以標準電阻箱（如圖二）輸出電阻值，以模擬 RTD 溫度感測元件之溫度變化。檢驗其溫度量測迴路之準確度，並比對與電腦圖控畫貌之顯示數值與現場實際模擬之輸入值是否相符。
- (2) 校驗時以電阻箱分次接於 5 個溫度信號迴路上(0%、25%、50%、75%及 100%)，並由電阻箱分別送出 171Ω、297Ω及 500Ω之電阻值，其對應之溫度分別是 -160℃、-100℃及 0℃三點，逐一進行量測並檢視其誤差是否合乎規格要求。
- (3) 經校驗量測 4 個貨艙內之主要及備援溫度量測系統準確度，其校驗結果均於誤差範圍內，符合要求。



圖二、標準電阻箱

### (三) CT-IV 壓力量測系統 (PRESSURE SYSTEM)

壓力量測方式為將所測得之壓力值，透過 FOXBORO 傳送器將信號傳送至工作站，其測試方式如下：

- (1) 以壓力信號產生器（如圖三）及數位式標準壓力表，測試壓力傳送器及其迴路之準確度，並比較工作站之圖控畫貌顯示值與印表機輸出之數據是否相符。
- (2) 測試前須先做數位式標準壓力表歸零校正。
- (3) 測試時先以壓力信號產生器接於迴路上，並依序分別將壓力往上送出 810、1100、1390 mbarA 之壓力信號，逐一進行量測並檢視其誤差是否合乎規格要求。
- (4) 後依序分別將壓力往下送出 1390、1100、810 mbarA 之壓力信號，逐一進行量測並檢視其誤差是否合乎規格要求。
- (5) 最後將二者之量測值取平均值後比對其差異，校驗結果均於誤差範圍內，符合要求。

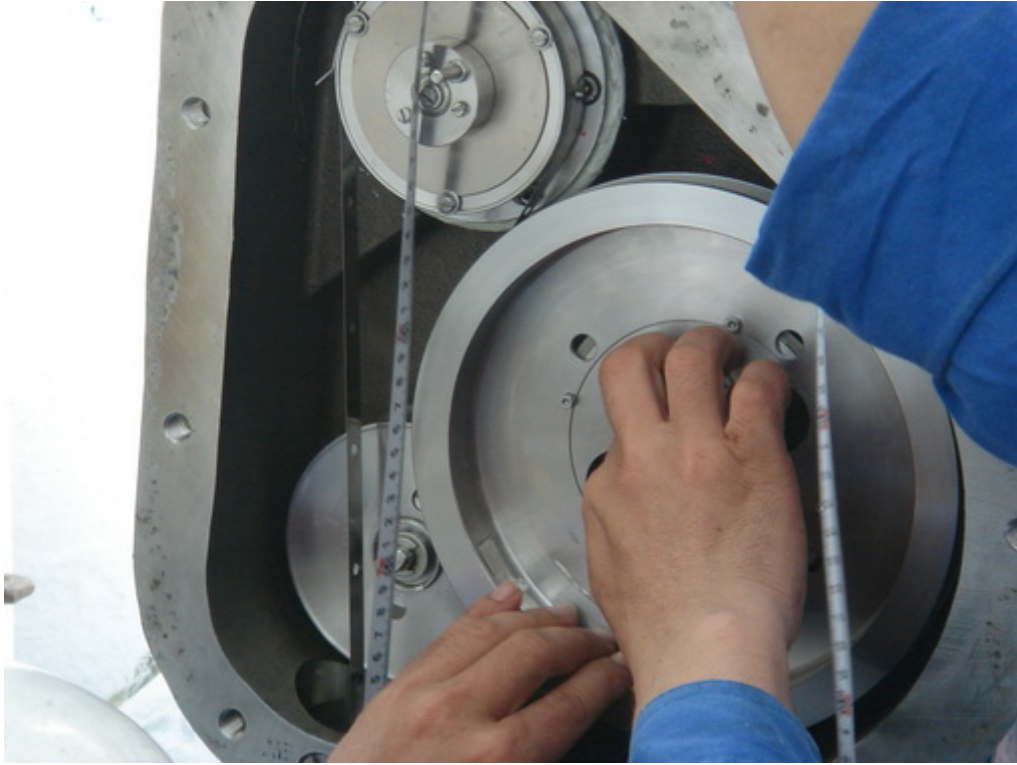


圖三、壓力信號產生器

#### (四) 浮球式液位計量測系統 (FLOAT LEVEL GAUGE)

- (1) 將浮球降至 COLUMN 最底部，以標準鋼尺測量浮球導線從船艙槽頂至槽底最大長度，校正其零點位置 (如圖四)。
- (2) 做完零點校正後，將浮球上升至船艙 20% (5100mm) 之高度，以標準鋼尺量測其實際高度，重複量測 3 次，分別記錄鋼尺量測值與液位計讀值。
- (3) 將浮球上升至船艙 80% (20400mm) 之高度，以標準鋼尺量測其實際高度，重複量測 3 次，分別記錄鋼尺量測值與液位計讀值。
- (4) 經校驗量測 4 個貨艙內浮球式液位計零點校正及上述二點高度值，其校驗結果均於誤差範圍內，符合要求。。
- (5) 經檢驗符合標準後，其浮球式液位計量錶由日本海事檢定協會人員鉛封 (如圖五)，有效期為期 2 年，惟如於有效期內有進行維修或其他變動後，即需重新校驗，以維持其準確性及公正性。





圖四、標準鋼尺測量



圖五、液位計鉛封

#### 伍、心得與建議

- (一)由日本海事檢定協會出具其針對本次 PUTERI FIRUS LNG 船上 4 個船艙 MEMBRANE TANK 之計量量測設備之校驗報告，其量測及校驗結果均在容許誤差範圍內。

- (二) 此次參與計量設備量測及校驗工作之監證，讓筆者更了解本廠地下式 LNG 儲槽之液位量測設備與船艙之液位量測設備之差異性，如本公司永安廠採用 2 套之計量液位量測設備大致與本次船艙之浮球式液位計量測系統類似，惟電容式液位計本廠並無採用。但另外本公司台中廠接收站之儲槽液位量測設備，目前就設置雷達波、浮球式液位計及電容式液位計等 3 種型式液位計，可做為相互備援及比對用。
- (三) 此次所進行的以標準電阻箱及壓力信號產生器進行之溫度及壓力校驗方式，與本公司永安廠日常所進行之儀器校驗方式並無太大差異。另以標準鋼尺進行浮球式液位計的檢測方式，因需於 LNG 儲槽清空時進行，並無法適用於本公司永安廠之 LNG 儲槽之液位量測設備。
- (四) LNG 船計量設備進行校驗工作期間，於 MMHE 進入 LNG 船時，需換上其連身式工作服，個人標準裝備包括安全鞋、護目鏡及安全掛鉤，並配帶識別標章。雖然此次與 MLNG 的人員進入 LNG 船僅做船艙計量系統的校驗之監證工作，但 MMHE 的工作人員也向我們解釋，這是只要進入目前於檢修階段都的 LNG 船人員，都需依此套標準作業程序進行。另如相關人員於登船時，需於旋梯前經刷卡並確認身份才得進入，由此可見不論是在國外或國內，對於工作人員自身的工安要求及人員的管理，大家都是一致嚴格要求及努力的目標。

## 六、附件

- (一) 本次 PUTERI FIRUS LNG 船 FLOAT LEVEL GAUGE 校驗報告。
- (二) 本次 PUTERI FIRUS LNG 船船艙計量系統 CT-IV 校驗報告。
- (三) 本次所使用之校驗儀器（包括標準電阻箱、壓力信號產生器及標準鋼尺）之實驗室檢測報告。



NIPPON KAIJI KENTEI KYOKAI  
SINGAPORE OFFICE

PROCEDURE & TEST RESULTS

OF

CTMS ONBOARD TEST ON

S.S. "PUTERI FIRUS"

NOVEMBER 2009

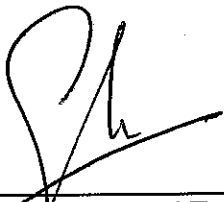
MALAYSIA MARINE AND HEAVY ENGINEERING SDN. BHD.

JOHOR , MALAYSIA

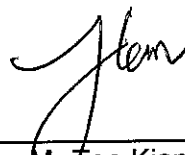
- \* FLOAT LEVEL GAUGE
- \* CT-IV LEVEL SYSTEM
- \* CT-IV TEMPERATURE SYSTEM (MAIN & BACKUP)
- \* CT-IV PRESSURE SYSTEM
- \* CT-IV TRIM & LIST

**CUSTODY TRANSFER MEASURING SYSTEM  
FOR  
S.S. " PUTERI FIRUS "**

This is to confirm that all the test carried out on 1st and 2nd November 2009 onboard vessel S.S. " PUTERI FIRUS " at MALAYSIA MARINE AND HEAVY ENGINEERING SDN. BHD. which comply with the procedure witnessed by the following persons.



Mr Shahrul Effendy Ahmad Tajudin  
SHAHRUL EFFENDY AHMAD TAJUDIN  
ENGINEER SUPERINTENDENT  
FLEET MANAGEMENT SERVICES



Mr Teo Kian Han  
NKKK Singapore

PUTERI FIRUS  
PORT KELANG  
O.N. 327334 G.T. 86205  
S.H.P 26750kW N.T. 25861



Capt. Khairuddin Shah B. Dato' Hj Aman Shah  
Master

CUSTODY TRANSFER MEASURING SYSTEM  
FOR  
S.S. "PUTERI FIRUS"

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## SUMMARY OF CTMS ONBOARD TEST RESULTS

### S.S. "PUTERI FIRUS "

PLACE : MALAYSIA MARINE AND HEAVY ENGINEERING SDN. BHD.  
 DATE : 3rd November 2009

Float Type Level Gauge	Maximum Error	Criteria
Local	4 mm	± 7.5mm

Main Gauge	Max. Sensor Error (ES) mm	Max. Error (ED) mm	Integrated Error (mm)	Criteria/ Spec.
Capacitance Type Level Gauge CRT / VDU ( XP1 & XP2 )	1.3	1.0	1.6	± 7.5mm

Temperature Measuring System XP1	Main Max. Error	Backup Max. Error	Criteria/ Spec.
@ -160 °C	0.02 °C	0.04 °C	± 0.2 °C
@ -100 °C	0.04 °C	0.04 °C	± 1.5 °C
@ 0 °C	0.05 °C	0.05 °C	± 1.5 °C
Temperature Measuring System XP2	Main Max. Error	Backup Max. Error	Criteria/ Spec.
@ -160 °C	0.02 °C	0.04 °C	± 0.2 °C
@ -100 °C	0.04 °C	0.04 °C	± 1.5 °C
@ 0 °C	0.05 °C	0.05 °C	± 1.5 °C

Pressure Gauge ( 800 to 1400 mbarA )	Max. Error	Max. Error %	Criteria
XP1	0.7 mbarA	0.12	±1% (6mbarA)
XP2	0.7 mbarA	0.12	

Trim 16.12m (B/S) to 8.06m (B/H)	Max. Error (ED)	Int. Error	CRITERIA
XP1	0.00	0.00	± 0.5%
XP2	0.00	0.00	
List (13.02° Port to 13.02° Starboard)	Max. Error (ED)	Int. Error	CRITERIA
XP1	0.00	0.00	± 0.5%
XP2	0.00	0.00	

\* ED : Maximum Display Error  
 ES : Shop Test Maximum Error

## **Accuracy Test of Float Gauge for vessel S.S. " PUTERI FIRUS "**

### **Accuracy Test**

Taking the float up to 20% ( 5100 mm ) of tank height and measure the height of the float by steel tape.

Moving the float up and down slightly, repeat the measurement 3 times. Height measured as above shall be averaged then the difference between the averaged height and the simulated level shall be calculated.

Move the float up to 80% ( 20400 mm ) of tank height and repeat the above procedure.

### **Integrated Error**

Larger difference calculated at 2 test levels is adopted as maximum error of the float gauge

### **Seal**

Gauge head of each float gauge shall be sealed by the customs officer or by NKKK surveyor.

### **Remark**

- (a) Locking the float with a plunger at top storage position, the indication shall be noted as maximum indication.
- (b) Minimum reading shall be confirmed.

**ACCURACY TEST OF FLOAT LEVEL GAUGE SYSTEM**

DATE : 1st and 2nd November 2009

VESSEL NAME : S.S. "PUTERI FIRUS"  
 PLACE : MALAYSIA MARINE AND HEAVY ENGINEERING SDN. BHD.

Temperature Correction (mm) : 14E-6 x L x (T-20)		Tension Correction (mm) : 3.685E-6 x L x 50 N		
Tank No.	1	2	3	4
Serial No.	3995 7	3995 8	3995 6	3995 5
Set Point	199	196	196	198
Counter	199	196	197	198
Error	0	0	1	0
Tank Temperature °C	25.4	24.6	24.7	25.9
1/5 Temperature Correction	0	0	0	0
1/5 Tension Correction	-1	-1	-1	-1
<b>Correction = Counter - Tape</b>				
	Counter	Tape	Correction	Counter
	1000	376	624	1000
	Counter Value	Measure Value	Actual Value	Counter Value
1/5 Tank Height	5,100	4,476	5,099	5,100
Checkpoint	5,100	4,475	5,098	5,100
(TANK NO.1-4 : 5100)	5,100	4,475	5,098	5,100
Ave.	5,100	4,475	5,098	5,100
Diff.	2	2	2	3
4/5 Temperature Correction	+1	+1	+1	+2
4/5 Tension Correction	-4	-4	-4	-4
	Counter	Measure Value	Actual Value	Counter
	20,400	19,776	20,397	20,400
4/5 Tank Height	20,400	19,776	20,397	20,400
Checkpoint	20,400	19,775	20,397	20,400
(TANK NO.1 - 4 : 20400)	20,400	19,777	20,398	20,400
Ave.	20,400	19,776	20,397	20,400
Diff.	3	3	3	4
Maximum Reading (Local)	28,689		28,682	
Unit : mm	Whessoe Fig. 3304		28,682	

Accuracy Check



## Accuracy Test of Capacitance Type Level Measurement System

### Objective

Test the

- Computer
- Stored Values
- Dry Cal
- Configuration

Procedure

- Perform Dry Cal via the workstation
- Call up the Dry Test function via the workstation
- Verify and record the empty values on the appropriate form attached.

The dry test function is performed in two steps :

- EMPTY values
- FULL values

For the EMPTY values the Dry Test function computes the liquid level in each segment using the actual values of each segment and the values stored by the Dry Cal and the configuration. The expected results are 0000.

For the FULL values the Dry Test function computes the liquid level in each segment using the simulated full values. The expected results are shown on the data sheets.

- The expected results are
- The length of the segment at the temperature indicated by the temperature system.
  - The full segment top height at the temperature indicated by the temperature system.

The column height error shall be confirmed.

The RSS ( Root Sum Squared) of the maximum difference shall be confirmed based on the following formula.

$$E_1 = \sqrt{ES^2 + ED^2}$$

$E_1$  : Maximum system error

ES : Maximum error of the sensor linearity

ED : Maximum error of the computer

**CT-IV TEST DATA FOR CAPACITANCE LEVEL SYSTEM**

Tank No. 1 - Main

TOL. : ± 7.5 mm

VESSEL : S.S. "PUTERI FIRUS"

In-Tank Temp : 25 °C

DATE : 1st and 2nd November 2009

XP1

Channel	Empty Channel Value (m)	Full Segment Length Value (m)	Segment Length Per Table 1 (m)	Segment Length Error (mm)	Column Height At Top Of Flange (m)	Column Height Per Table 2 (m)	Column Height Error (mm)
Ref -	0.000	0.360	0.360	0	0.386	0.386	0
First (1)	0.000	4.991	4.992	1	5.018	5.018	0
Second (2)	0.000	5.019	5.018	1	10.037	10.036	1
Third (3)	0.000	2.710	2.710	0	12.746	12.746	0
Fourth (4)	0.000	2.609	2.609	0	15.355	15.355	0
Fifth (2)	0.000	5.019	5.018	1	20.374	20.373	1
Sixth (5)	0.000	5.021	5.022	1	25.394	25.395	1

XP2

Channel	Empty Channel Value (m)	Full Segment Length Value (m)	Segment Length Per Table 1 (m)	Segment Length Error (mm)	Column Height At Top Of Flange (m)	Column Height Per Table 2 (m)	Column Height Error (mm)
Ref -	0.000	0.360	0.360	0	0.386	0.386	0
First (1)	0.000	4.991	4.992	1	5.018	5.018	0
Second (2)	0.000	5.019	5.018	1	10.037	10.036	1
Third (3)	0.000	2.710	2.710	0	12.746	12.746	0
Fourth (4)	0.000	2.609	2.609	0	15.355	15.355	0
Fifth (2)	0.000	5.019	5.018	1	20.374	20.373	1
Sixth (5)	0.000	5.021	5.022	1	25.394	25.395	1

- Note:
- (1) Segment Length Error = Full Segment Length Value - Segment Length Per Table 1
  - (2) Column Height Error = Column Height At Top Of Flange - Column Height Per Table 2
  - (3) Number In Bracket ( ) Means The Kind Of Segment Shown In Table 1 attached

Column Height Maximum Error (XP1)                      1 mm  
 Column Height Maximum Error (XP2)                      1 mm







VESSEL NAME : S.S. " PUTERI FIRUS "

Table 1: Full Segment Length (Meter)

Segment Type	Temperature °C										
	@ 25	24	25	26	27	28	29	30	31	32	33
Reference -	0.360	0.360	0.360	0.360	0.360	0.360	0.360	0.360	0.360	0.360	0.360
Reference/Support (1)	4.992	4.992	4.992	4.992	4.992	4.992	4.992	4.992	4.993	4.993	4.993
Standard Segment (2)	5.018	5.018	5.018	5.018	5.018	5.018	5.018	5.018	5.019	5.019	5.019
Special Segment (3)	2.710	2.710	2.710	2.710	2.710	2.710	2.710	2.710	2.710	2.710	2.710
Special Segment (4)	2.609	2.609	2.609	2.609	2.609	2.609	2.609	2.609	2.609	2.609	2.609
Top Segment (5)	5.022	5.022	5.022	5.022	5.022	5.022	5.022	5.022	5.023	5.023	5.023

Table 2: Column Height (Meter)

Segment Type	Temperature °C										
	@ 25	24	25	26	27	28	29	30	31	32	33
Ref -	0.386	0.386	0.386	0.386	0.386	0.386	0.386	0.386	0.386	0.386	0.386
First (1)	5.018	5.018	5.018	5.018	5.018	5.018	5.018	5.018	5.019	5.019	5.019
Second (2)	10.036	10.036	10.036	10.036	10.036	10.037	10.037	10.037	10.037	10.037	10.038
Third (3)	12.746	12.746	12.746	12.746	12.747	12.747	12.747	12.747	12.748	12.748	12.748
Fourth (4)	15.355	15.355	15.355	15.355	15.356	15.356	15.356	15.357	15.357	15.357	15.358
Fifth (2)	20.373	20.373	20.373	20.373	20.374	20.374	20.375	20.375	20.376	20.376	20.377
Sixth (5)	25.395	25.394	25.395	25.396	25.396	25.397	25.397	25.398	25.398	25.399	25.399

This table is made using the next formula:

$$H^t = (1 + a \times (t - 25)) \times H$$

Where:  $a = 21.96 \times 10^{-6}$

H = Full Segment Length at 25 °C

H<sup>t</sup> = Full Segment Length at t °C

## Accuracy Test of Temperature Measuring System

### Resistance Thermal Detector (RTD)

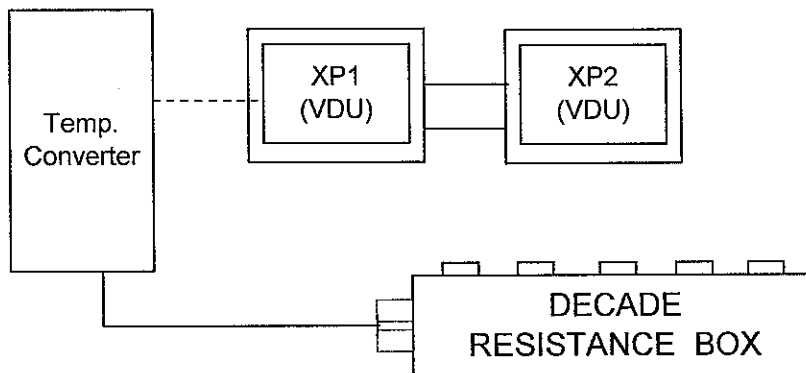
Condition of cabling and mounting of the RTDs shall visually be inspected.

### Display and Printer

Feed 500 ohm, 297 ohm and 171 ohm which represent 0 °C, -100 °C and -160 °C respectively to the temperature converter from a precision decade resistance box. Compare the temperature output from the XP1 and XP2 with each RTD's characteristics.

### Integrated Error

The maximum difference between the temperature output from the Displays ( XP1 & XP2 ) and the RTD's characteristics shall be regarded as the integrated error.





**CT-IV TEST DATA FOR TEMPERATURE SYSTEM**

Tank No. : 1  
 Tolerance : ± 0.2 °C (-165 °C to -145 °C) ± 1.5 °C (-145 °C to +40 °C)  
 Vessel Name : S.S. " PUTERI FIRUS "  
 Date : 1st and 2nd November 2009

**Main**

Fitting Location	100%		75%		50%		25%		0%	
	Serial Number	Value	Serial Number	Value	Serial Number	Value	Serial Number	Value	Serial Number	Value
Sensor Characteristic For Test Kit (Standard Temperature)	171 Ohm	-160.14	F46736-A1	F46736-A2	F46736-A5	F30350-A13	F43954-A44	-160.30	-160.30	-160.30
	297 Ohm	-100.05		-100.35	-100.02	-100.35	-100.31	-100.31	-100.31	-100.31
	500 Ohm	0.25		-0.28	0.27	-0.23	-0.16	-0.16	-0.16	-0.16
Data Source	Actual	XP1	XP2	XP1	XP2	XP1	XP2	XP1	XP2	XP1
	Indicated	-160.14	-160.14	-160.29	-160.12	-160.12	-160.30	-160.30	-160.30	-160.30
Temperature	171 Ohm	-100.04	-100.04	-100.31	-100.31	-100.00	-100.34	-100.29	-100.29	-100.29
	297 Ohm	0.27	0.27	-0.24	0.31	0.31	-0.19	-0.12	-0.12	-0.12
Error For Each	500 Ohm	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00
	-160 °C	0.01	0.01	0.04	0.02	0.02	0.01	0.02	0.02	0.02
Checkpoint	-100 °C	0.02	0.02	0.04	0.04	0.04	0.04	0.04	0.04	0.04
	0 °C	0.02	0.02	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Max. Error (XP1)		@ -160 °C @ -100 °C		@ -0 °C		Max. Error (XP2)		@ -160 °C @ -100 °C @ -0 °C		
		0.02		0.04		0.02		0.04		

**Backup**

Fitting Location	100%		75%		50%		25%		0%	
	Serial Number	Value	Serial Number	Value	Serial Number	Value	Serial Number	Value	Serial Number	Value
Sensor Characteristic For Test Kit (Standard Temperature)	171 Ohm	-160.10	F42541-A50	F49216-A8	F49216-A7	F49216-A10	-160.20	-160.20	-160.20	-160.20
	297 Ohm	-99.98	-100.36	-100.36	-99.98	-100.39	-100.19	-100.19	-100.19	-100.19
	500 Ohm	0.35	-0.22	0.45	-0.29	-0.02	-0.02	-0.02	-0.02	-0.02
Data Source	Actual	XP1	XP2	XP1	XP2	XP1	XP2	XP1	XP2	XP1
	Indicated	-160.11	-160.11	-160.31	-160.11	-160.34	-160.23	-160.23	-160.23	-160.23
Temperature	171 Ohm	-99.97	-99.97	-100.32	-99.99	-100.36	-100.18	-100.18	-100.18	-100.18
	297 Ohm	0.36	0.36	-0.18	0.46	0.46	-0.24	-0.01	-0.01	-0.01
Error For Each	500 Ohm	0.01	0.01	0.02	0.00	0.01	0.03	0.03	0.03	0.03
	-160 °C	0.01	0.01	0.04	0.01	0.01	0.03	0.01	0.01	0.01
Checkpoint	-100 °C	0.01	0.01	0.04	0.01	0.01	0.05	0.03	0.03	0.03
	0 °C	0.01	0.01	0.04	0.01	0.01	0.05	0.03	0.03	0.03
Max. Error (XP1)		@ -160 °C @ -100 °C		@ -0 °C		Max. Error (XP2)		@ -160 °C @ -100 °C @ -0 °C		
		0.03		0.04		0.03		0.04		

**CT-IV TEST DATA FOR TEMPERATURE SYSTEM**

Tank No. : 2  
 Tolerance : ± 0.2 °C (-165 °C to -145 °C) ± 1.5 °C (-145 °C to +40 °C)  
 Vessel Name : S.S. " PUTERI FIRUS "  
 Date : 1st and 2nd November 2009

**Main**

Fitting Location		100%		75%		50%		25%		0%	
Serial Number		F30350-A28	F49216-A15	F43954-A39	F43954-A42	F43954-A41					
Sensor Characteristic	171 Ohm	-160.24	-160.29	-160.35	-160.29	-160.17					
For Test Kit	297 Ohm	-100.24	-100.35	-100.34	-100.35	-100.10					
(Standard Temperature)	500 Ohm	-0.10	-0.31	-0.14	-0.32	0.14					
Data Source		XP1	XP2	XP1	XP2	XP1	XP2	XP1	XP2	XP1	XP2
Actual	171 Ohm	-160.26	-160.28	-160.26	-160.28	-160.33	-160.33	-160.29	-160.29	-160.17	-160.17
Indicated	297 Ohm	-100.26	-100.33	-100.26	-100.33	-100.31	-100.31	-100.34	-100.34	-100.09	-100.09
Temperature	500 Ohm	-0.10	-0.26	-0.10	-0.26	-0.12	-0.12	-0.29	-0.29	0.17	0.17
Error For	-160 °C	0.02	0.01	0.02	0.01	0.02	0.02	0.00	0.00	0.00	0.00
Each	-100 °C	0.02	0.02	0.02	0.02	0.03	0.03	0.01	0.01	0.01	0.01
Checkpoint	0 °C	0.00	0.05	0.02	0.05	0.02	0.02	0.03	0.03	0.03	0.03
		Max. Error (XP1)		@ -160 °C @ -100 °C @ -0 °C		Max. Error (XP2)		@ -160 °C @ -100 °C @ -0 °C			
		0.02		0.03		0.05		0.02		0.03	

**Backup**

Fitting Location		100%		75%		50%		25%		0%	
Serial Number		F34381-A8	F49216-A11	F43954-A37	F43954-A35	F43954-A40					
Sensor Characteristic	171 Ohm	-160.25	-160.36	-160.30	-160.38	-160.20					
For Test Kit	297 Ohm	-100.22	-100.47	-100.37	-100.40	-100.14					
(Standard Temperature)	500 Ohm	0.04	-0.44	-0.35	-0.27	0.08					
Data Source		XP1	XP2	XP1	XP2	XP1	XP2	XP1	XP2	XP1	XP2
Actual	171 Ohm	-160.29	-160.29	-160.35	-160.31	-160.31	-160.37	-160.37	-160.37	-160.20	-160.20
Indicated	297 Ohm	-100.25	-100.25	-100.46	-100.34	-100.34	-100.38	-100.38	-100.38	-100.12	-100.12
Temperature	500 Ohm	0.03	0.03	-0.39	-0.33	-0.33	-0.25	-0.25	-0.25	0.11	0.11
Error For	-160 °C	0.04	0.04	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00
Each	-100 °C	0.03	0.03	0.01	0.03	0.03	0.02	0.02	0.02	0.02	0.02
Checkpoint	0 °C	0.01	0.01	0.05	0.05	0.02	0.02	0.02	0.02	0.03	0.03
		Max. Error (XP1)		@ -160 °C @ -100 °C @ -0 °C		Max. Error (XP2)		@ -160 °C @ -100 °C @ -0 °C			
		0.04		0.03		0.05		0.04		0.03	

**CT-IV TEST DATA FOR TEMPERATURE SYSTEM**

Tank No. : 3  
 Tolerance : ± 0.2 °C (-165 °C to -145 °C) ± 1.5 °C (-145 °C to +40 °C)  
 Vessel Name : S.S. " PUTERI FIRUS "  
 Date : 1st and 2nd November 2009

**Main**

Fitting Location		100%		75%		50%		25%		0%	
Serial Number		F43954-A20	F43954-A19	F43954-A17	F43954-A16	F43954-A21					
Sensor Characteristic	171 Ohm	-160.29	-160.30	-160.21	-160.21	-160.23					
For Test Kit	297 Ohm	-100.31	-100.34	-100.19	-100.18	-100.18					
(Standard Temperature)	500 Ohm	-0.21	-0.24	-0.05	0.01	-0.05					
Data Source		XP1	XP2	XP1	XP2	XP1	XP2	XP1	XP2	XP1	XP2
Actual	171 Ohm	-160.29	-160.29	-160.28	-160.28	-160.23	-160.19	-160.19	-160.19	-160.21	-160.21
Indicated	297 Ohm	-100.29	-100.29	-100.31	-100.31	-100.18	-100.14	-100.14	-100.14	-100.18	-100.18
Temperature	500 Ohm	-0.16	-0.16	-0.22	-0.22	-0.01	0.05	0.05	0.05	-0.01	-0.01
Error For	-160 °C	0.00	0.00	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Each	-100 °C	0.02	0.02	0.03	0.03	0.01	0.04	0.04	0.04	0.03	0.03
Checkpoint	0 °C	0.05	0.05	0.02	0.02	0.04	0.04	0.04	0.04	0.04	0.04
		Max. Error (XP1)		@ -160 °C @ -100 °C @ -0 °C		Max. Error (XP2)		@ -160 °C @ -100 °C @ -0 °C			
		0.02		0.04		0.05		0.02		0.04	

**Backup**

Fitting Location		100%		75%		50%		25%		0%	
Serial Number		F43954-A33	F43954-A47	F43954-A23	F43954-A29	F43954-A28					
Sensor Characteristic	171 Ohm	-160.28	-160.24	-160.30	-160.32	-160.27					
For Test Kit	297 Ohm	-100.28	-100.23	-100.33	-100.38	-100.25					
(Standard Temperature)	500 Ohm	-0.12	-0.09	-0.26	-0.34	-0.09					
Data Source		XP1	XP2	XP1	XP2	XP1	XP2	XP1	XP2	XP1	XP2
Actual	171 Ohm	-160.28	-160.28	-160.23	-160.32	-160.30	-160.30	-160.30	-160.30	-160.25	-160.25
Indicated	297 Ohm	-100.25	-100.25	-100.21	-100.32	-100.35	-100.35	-100.35	-100.35	-100.21	-100.21
Temperature	500 Ohm	-0.08	-0.08	-0.07	-0.21	-0.30	-0.30	-0.30	-0.30	-0.04	-0.04
Error For	-160 °C	0.00	0.00	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Each	-100 °C	0.03	0.03	0.02	0.01	0.03	0.03	0.03	0.03	0.04	0.04
Checkpoint	0 °C	0.04	0.04	0.02	0.05	0.04	0.04	0.04	0.04	0.05	0.05
		Max. Error (XP1)		@ -160 °C @ -100 °C @ -0 °C		Max. Error (XP2)		@ -160 °C @ -100 °C @ -0 °C			
		0.02		0.04		0.05		0.02		0.04	

**CT-IV TEST DATA FOR TEMPERATURE SYSTEM**

Tank No. : 4  
 Tolerance : ± 0.2 °C (-165 °C to -145 °C) ± 1.5 °C (-145 °C to +40 °C)  
 Vessel Name : S.S. " PUTERI FIRUS "  
 Date : 1st and 2nd November 2009

**Main**

Fitting Location	100%		75%		50%		25%		0%	
	Serial Number	Value	Serial Number	Value	Serial Number	Value	Serial Number	Value	Serial Number	Value
Sensor Characteristic	F43954-A31		F43954-A26		F43954-A27		F43954-A36		F43954-A18	
For Test Kit	171 Ohm	-160.30	-160.43	-160.23	-160.23	-160.24	-160.22	-160.16	-160.16	-100.07
(Standard Temperature)	297 Ohm	-100.32	-100.40	-100.23	-100.23	-100.22	-100.22	-100.07	-100.07	0.24
Data Source	500 Ohm	-0.20	-0.34	-0.09	-0.02	-0.02	-0.02	-0.02	-0.02	
Actual	XP1	XP2	XP1	XP2	XP1	XP2	XP1	XP2	XP1	XP2
Indicated	-160.29	-160.29	-160.42	-160.42	-160.21	-160.21	-160.26	-160.26	-160.15	-160.15
Temperature	297 Ohm	-100.29	-100.37	-100.37	-100.21	-100.21	-100.19	-100.19	-100.04	-100.04
Error For	500 Ohm	-0.18	-0.32	-0.32	-0.06	-0.06	0.01	0.01	0.21	0.21
Each	-160 °C	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.01	0.01
Checkpoint	-100 °C	0.03	0.03	0.03	0.02	0.02	0.03	0.03	0.03	0.03
	0 °C	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03
		Max. Error (XP1)		@ -160 °C @ -100 °C @ -0 °C		Max. Error (XP2)		@ -160 °C @ -100 °C @ -0 °C		
		0.02	0.03	0.03	0.03	0.02	0.02	0.03	0.03	0.03

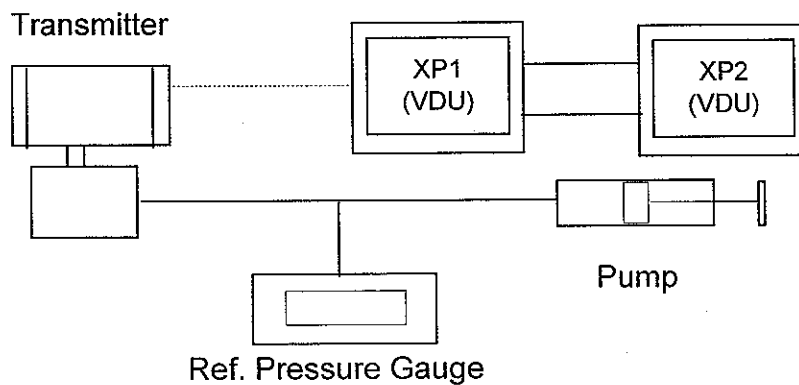
**Backup**

Fitting Location	100%		75%		50%		25%		0%	
	Serial Number	Value	Serial Number	Value	Serial Number	Value	Serial Number	Value	Serial Number	Value
Sensor Characteristic	F43954-A32		F43954-A45		F43954-A24		F43954-A30		F43954-A22	
For Test Kit	171 Ohm	-160.27	-160.17	-160.22	-160.22	-160.31	-160.22	-160.22	-160.22	-100.20
(Standard Temperature)	297 Ohm	-100.29	-100.11	-100.15	-100.35	-100.20	-100.20	-100.20	-100.20	-0.06
Data Source	500 Ohm	-0.17	0.10	0.12	-0.28	-0.06	-0.06	-0.06	-0.06	
Actual	XP1	XP2	XP1	XP2	XP1	XP2	XP1	XP2	XP1	XP2
Indicated	-160.26	-160.26	-160.16	-160.16	-160.19	-160.19	-160.33	-160.33	-160.20	-160.20
Temperature	297 Ohm	-100.27	-100.08	-100.08	-100.13	-100.13	-100.33	-100.33	-100.18	-100.18
Error For	500 Ohm	-0.17	0.13	0.13	0.16	0.16	-0.23	-0.23	-0.05	-0.05
Each	-160 °C	0.01	0.01	0.01	0.03	0.03	0.02	0.02	0.02	0.02
Checkpoint	-100 °C	0.02	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02
	0 °C	0.00	0.03	0.03	0.04	0.04	0.05	0.05	0.01	0.01
		Max. Error (XP1)		@ -160 °C @ -100 °C @ -0 °C		Max. Error (XP2)		@ -160 °C @ -100 °C @ -0 °C		
		0.00	0.03	0.03	0.05	0.03	0.03	0.03	0.03	0.05

## Accuracy Test of Pressure Measuring System

Pressure transmitter, XP1 and XP2

Each pressure transmitter, a reference pressure gauge and a hand pump shall be connected as shown below. Simulated pressure of 810, 1100 & 1390 mbarA is introduced to the transmitter. The test shall be repeated for increasing and decreasing pressure. The readout is recorded from the display ( XP1 and XP2 )



Integrated Error

The maximum difference between the output from the displays ( XP1 & XP2 ) and the given pressure from the reference pressure gauge shall be defined as error of the pressure measurement.

**CT-IV TEST DATA FOR PRESSURE SYSTEM FOR VESSEL S.S. "PUTERI FIRUS"**

Ambient Temperature : 29 °C      Date : 1st and 2nd November 2009

Atmospheric Pressure : 1009 mbarA      Tolerance : ± 1% OF FULL SPAN (± 6 mbarA)

Tank No.	Serial No.	Test Pressure (mbarA) Readout (G)	DATA READOUT (mbarA)		Average Output (C) = (A+B)/2		Error (mbarA) (E) = (C-G)			
			Increasing (A)	Decreasing (B)	XP1	XP2	XP1	XP2		
1	06181714	810	810.3	810.3	810.7	810.7	810.5	810.5	0.5	0.5
		1100	1100.4	1100.4	1100.6	1100.6	1100.5	1100.5	0.5	0.5
		1390	1390.5	1390.5	1390.6	1390.6	1390.6	1390.6	0.6	0.6
2	07241705	810	810.2	810.2	810.3	810.3	810.3	810.3	0.3	0.3
		1100	1100.3	1100.3	1100.3	1100.3	1100.3	1100.3	0.3	0.3
		1390	1390.5	1390.5	1390.8	1390.8	1390.7	1390.7	0.7	0.7
3	04351618	810	810.0	810.0	809.9	809.9	810.0	810.0	0.0	0.0
		1100	1100.3	1100.3	1100.0	1100.0	1100.2	1100.2	0.2	0.2
		1390	1390.5	1390.5	1390.1	1390.1	1390.3	1390.3	0.3	0.3
4	08232094	810	810.1	810.1	810.2	810.2	810.2	810.2	0.2	0.2
		1100	1100.4	1100.4	1100.4	1100.4	1100.4	1100.4	0.4	0.4
		1390	1390.3	1390.3	1390.4	1390.4	1390.4	1390.4	0.4	0.4

Range of Pressure Transmitter : 800 mbarA to 1400 mbarA

Max. XP1 Error : 0.7 mbarA      Max. XP2 Error : 0.7 mbarA  
 XP1 (%) : 0.12 %      XP2 (%) : 0.12 %

## Accuracy Test of Trim and List Measuring System

### Inspection Procedure for Trim and List

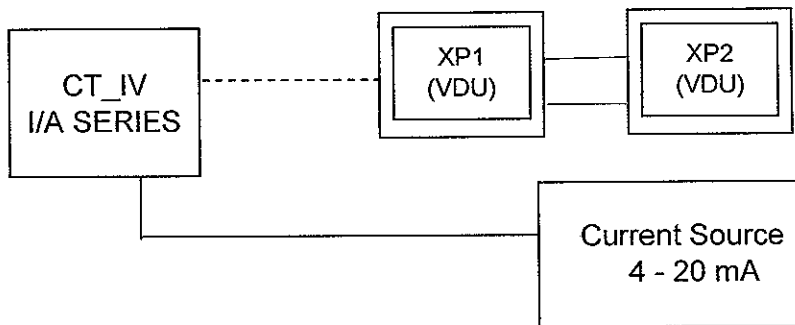
This procedure shall be applied to verify the Trim and List function used on Foxboro Custody Transfer System.

### Equipment Required

4 - 20 mA Precision current source with valid calibration certificate traceable to National Standard

### Setup

Connect as follows :



### Trim

Set related blocks of column C to manual and set simulated values.

Simultaneously input 4 ~ 20 mA DC test signal to block "T\_Har". Record values and fill in column A.

Same procedure as in step 1 but input 4 ~ 20 mA DC test signal to block "T\_Hav".

Record values and fill in column B.

Set related blocks of column C to manual and set simulated values. Simultaneously set blocks "T\_Har" and "T-Hav" to manual and set recorded values (column A & B) and take reading for XP1 and XP2

### List

Input 4 ~ 20 mA DC test signal to block "L\_Port". Record values and fill column A.

Input 4 ~ 20 mA DC test signal to block "L\_Stbd". Record values and fill column B.

Set blocks "L\_Port" and "L\_Stbd" to manual and set recorded values (column A & B) and take reading for XP1 and XP2

### Trim & List Calibration Data

Vessel Name : S.S. " PUTERI FIRUS "

Place : MALAYSIA MARINE AND HEAVY ENGINEERING SDN. BHD.

Date : 1st and 2nd November 2009

Trim Range : 16.12 m (B/S) to 8.06 m (B/H)

After Drought		Fore Drought		Input Simulated List (Degrees) (C)	Simulated Trim (Meters)	XP1		XP2	
Input (mA DC) Test Signal	Block Reading (T_Har) (A)	Input (mA DC) Test Signal	Block Reading (T_Hav) (B)			Actual	Error	Actual	Error
20	14.902	4	1.592	13.02 (P)	16.12 (B/S)	16.12 (B/S)	0.00	16.12 (B/S)	0.00
12	10.020	12	6.469	0.00	4.03 (B/S)	4.03 (B/S)	0.00	4.03 (B/S)	0.00
4	5.142	20	11.351	13.02 (S)	8.06 (B/H)	8.06 (B/H)	0.00	8.06 (B/H)	0.00

Tolerance Limit :  $\pm 0.5\%$  including transmitter error.

1. Set related blocks of column C to manual and set simulated values. Simultaneously input 4 ~ 20 mA DC test signal to block "T\_Har". Record values and fill in column A.
2. Same procedure as in step 1 but input 4 ~ 20 mA DC test signal to block "T\_Hav". Record values and fill in column B.
3. Set related blocks of column C to manual and set simulated values. Simultaneously set blocks "T\_Har" and "T-Hav" to manual and set recorded values (column A & B) and take reading for XP1 and XP2

List Range : Port 13.02° to Starboard 13.02°

Port		Starboard		Simulated List (Degrees)	XP1		XP2	
Input (mA DC) Test Signal	Block Reading (L_Port) (A)	Input (mA DC) Test Signal	Block Reading (L_Stbd) (B)		Actual	Error	Actual	Error
20	12.861	4	3.102	13.02 (P)	13.02 (P)	0.00	13.02 (P)	0.00
12	7.979	12	7.980	0.00	0.00 (P)	0.00	0.00 (P)	0.00
4	3.102	20	12.861	13.02 (S)	13.02 (S)	0.00	13.02 (S)	0.00

Tolerance Limit :  $\pm 0.5\%$  including transmitter error.

1. Input 4 ~ 20 mA DC test signal to block "L\_Port". Record values and fill column A.
2. Input 4 ~ 20 mA DC test signal to block "L\_Stbd". Record values and fill column B.
3. Set blocks "L\_Port" and "L\_Stbd" to manual and set recorded values (column A & B) and take reading for XP1 and XP2



ORIGINAL

**STANDARD GENERAL SUPERINTENDENCE TESTING LABORATORY PTE LTD**  
**[SGSTL] [INTERNATIONAL INSPECTION & TESTING]**

BLK 2022 #04-174 BUKIT BATOK IND. PARK ST. 23 SINGAPORE 659527

TEL: [65] 6563 7866 FAX: [65] 6560 1491 MOBILE: [65] 9668 9770 EMAIL: sgstl@pacific.net.sg

TAPE.MEASURE 50000 mm 'KDS'  
S175-1 NKKK. 0905 C 69

CAL DATE: 11.05.2009  
DUE DATE: 11.05.2010

**CALIBRATION REPORT**

APPLICANT: M/S NIPPON KAJI KENTEI KYOKAI 62731411

EQUIPMENT: MEASURING TAPE BRAND: 'KDS' TYPE: STEEL  
LENGTH: 50000 mm GRADUATION: 1 mm SERIAL # S175-1  
MARK: MAKE: JAPAN

TEST CONDITION: TEMPERATURE: 20 C HUMIDITY: 55 %

**RESULT OF CALIBRATION:**

LENGTH: UNIT: mm MEASURED @ 50 N TENSION

REAL	READ	CORR.	% READ DISCREPANCY
1000.0	1000	0	0
5000.0	5000	0	0
10000.0	10000	0	0
15000.0	15000	0	0
20000.0	20000	0	0
25000.0	25000	0	0
30000.0	30000	0	0
35000.0	35000	0	0
40000.0	40000	0	0
45000.0	45000	0	0
50000.0	50000	0	0

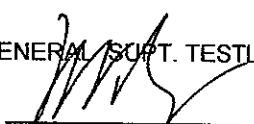
**INSPECTION:**

NO SEVERE TWIST NOR BEND OVER THE OTHER LENGTH OF TAPE  
A SHORT SECTION @ 1 M, 4 M, 19 M, 34 M  
WHICH HAVE A SLIGHT KINK  
HAVE NO EFFECT ON ACCURACY UNDER A TENSION PULL OF 50 N  
THE GRADUATION MARKINGS ARE BRIGHT & CLEAR.

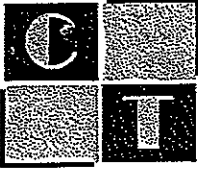
**CERTIFICATION:** THE CALIBRATION SHOW MEASURING TAPE TYPE: STEEL  
BRAND: 'KDS' LENGTH: 50000 mm GRADUATION: 1 mm SERIAL # S175-1  
WHICH HAS AN ACCURACY WITH TOLERANCE < 0.01 % DISCREPANCY OF TAPE READING,  
IS IN CONFORMANCE WITH JIS B7512 1<sup>ST</sup>. CLASS STANDARD SPECIFICATIONS.

THE ESTIMATED UNCERTAINTY OF MEASUREMENT ASSOCIATED WITH THE TAPE READING IS  
< +/- 0.5 mm @ A CONFIDENCE LEVEL OF > 95 %.

STD. GENERAL SUPT. TESTLAB

  
M. K. TIANG / Manager

EQ 114



# CALTEK PTE LTD

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Tel: (65) 6452 0300 Fax: (65) 6452 0500

Email: caltek@singnet.com.sg Website: www.caltek.com.sg

## CALIBRATION CERTIFICATE

**CERTIFICATE NUMBER** : CE 1312-09      **JOB NUMBER** : CTJ 2644-09  
**DATE RECEIVED** : 15-Apr-09      **ISSUE DATE** : 21-Apr-09

<b>Instrument</b> : RESISTANCE BOX	<b>Ambient Temperature</b> : $21 \pm 2^\circ \text{C}$
<b>Manufacturer</b> : TIME ELECTRONICS	<b>Relative Humidity</b> : $55 \pm 10\% \text{ r.h.}$
<b>Model No.</b> : 1041	<b>Date Calibrated</b> : 21-Apr-09
<b>Serial No.</b> : 4308C06	<b>Recommended Due Date</b> : 21-Apr-10
<b>Customer</b> : <b>Invensys Process Systems (S) Pte Ltd</b>	<b>Range</b> : ---
15, Changi Business Park Central 1	( Tag No. ) : ---
Singapore 486057	<b>Page</b> : 1 of 3
	<b>Status</b> : As Found

The described instrument has been calibrated at **Caltex Laboratory** under the ambient conditions stated above.

**Caltex** organisation and practices are in compliance with **ISO/IEC 17025**. The Quality System is in accordance with the **Quality Standard ISO 9001:2000**.

The reference measurement standards used are traceable to **(NMC)**, Singapore and **National Physical Laboratory (NPL)**, UK and **National Institute of Standards and Technology (NIST)**, USA or other recognised National or International Standards Laboratories.

### METHOD OF CALIBRATION

- The calibration method was carried out by In-house Technical Calibration Procedure CT-E06:2007 as a guide.

### REFERENCE STANDARD(S) USED FOR CALIBRATION

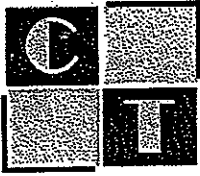
<u>INSTRUMENT</u>	<u>S/N</u>
1. Digital Precision Multimeter	3146A30845

### RESULTS OF CALIBRATION

- The results of calibration are given on the attached calibration data sheet(s).
- The expanded uncertainty of measurement associated with the calibration is  $\pm 0.24\%$  of reading estimated at a confidence level of approximately 95% with a coverage factor of  $k = 2$ .
- The user should determine the suitability of the instrument for its intended use.

**O.M. Yasir**  
Calibration Officer

**G. Anand**  
Approved by



# CALTEK PTE LTD

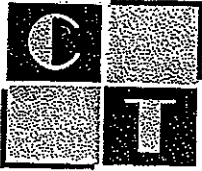
23 Tagore Lane, #03-19 Tagore 23 Warehouse, Singapore 787601  
Tel: (65) 6452 0300 Fax: (65) 6452 0500  
Email: caltek@singnet.com.sg Website: www.caltek.com.sg

## CALIBRATION CERTIFICATE

CERTIFICATE NUMBER : CE 1312-09  
ISSUED DATE : 21-Apr-09

JOB NUMBER : CTJ 2644-09  
PAGE : 2 of 3

Instrument Readings	Actual Values	Low Limit	High Limit	Remark / Status
<b>INDIVIDUAL RESISTANCE</b>	0.057 $\Omega$			
<b>0.01 <math>\Omega</math> Step</b>				
0.01 $\Omega$	0.009	0.0090	0.0110	Pass
0.02 $\Omega$	0.020	0.0180	0.0220	Pass
0.03 $\Omega$	0.029	0.0270	0.0330	Pass
0.04 $\Omega$	0.039	0.0360	0.0440	Pass
0.05 $\Omega$	0.490	0.0450	0.0550	Pass
0.06 $\Omega$	0.059	0.0540	0.0660	Pass
0.07 $\Omega$	0.071	0.0630	0.0770	Pass
0.08 $\Omega$	0.078	0.0720	0.0880	Pass
0.09 $\Omega$	0.089	0.0810	0.0990	Pass
<b>0.1 <math>\Omega</math> Step</b>				
0.10 $\Omega$	0.101	0.0950	0.1050	Pass
0.20 $\Omega$	0.203	0.1900	0.2100	Pass
0.30 $\Omega$	0.299	0.2850	0.3150	Pass
0.40 $\Omega$	0.418	0.3800	0.4200	Pass
0.50 $\Omega$	0.502	0.4750	0.5250	Pass
0.60 $\Omega$	0.614	0.5700	0.6300	Pass
0.70 $\Omega$	0.711	0.6650	0.7350	Pass
0.80 $\Omega$	0.807	0.7600	0.8400	Pass
0.90 $\Omega$	0.896	0.8550	0.9450	Pass
<b>1.0 <math>\Omega</math> Step</b>				
1.00 $\Omega$	1.002	0.9900	1.0100	Pass
2.00 $\Omega$	2.002	1.9800	2.0200	Pass
3.00 $\Omega$	3.012	2.9700	3.0300	Pass
4.00 $\Omega$	4.003	3.9600	4.0400	Pass
5.00 $\Omega$	5.014	4.9500	5.0500	Pass
6.00 $\Omega$	5.981	5.9400	6.0600	Pass
7.00 $\Omega$	6.996	6.9300	7.0700	Pass
8.00 $\Omega$	7.994	7.9200	8.0800	Pass
9.00 $\Omega$	8.995	8.9100	9.0900	Pass
<b>10 <math>\Omega</math> Step</b>				
10.00 $\Omega$	10.031	9.9500	10.0500	Pass
20.00 $\Omega$	20.048	19.9000	20.1000	Pass
30.00 $\Omega$	30.042	29.8500	30.1500	Pass
40.00 $\Omega$	40.026	39.8000	40.2000	Pass
50.00 $\Omega$	50.064	49.7500	50.2500	Pass
60.00 $\Omega$	60.084	59.7000	60.3000	Pass
70.00 $\Omega$	70.088	69.6500	70.3500	Pass
80.00 $\Omega$	80.112	79.6000	80.4000	Pass
90.00 $\Omega$	90.112	89.5500	90.4500	Pass



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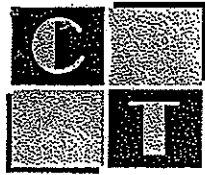
23 Tagore Lane, #03-19 Tagore 23 Warehouse, Singapore 787601  
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Email: caltek@singnet.com.sg Website: www.caltek.com.sg

## CALIBRATION CERTIFICATE

CERTIFICATE NUMBER : CE 1312-09  
ISSUED DATE : 21-Apr-09

JOB NUMBER : CTJ 2644-09  
PAGE : 3 of 3

Instrument Readings	Actual Values	Low Limit	High Limit	Remark / Status
10u $\Omega$ Step				
100.00 $\Omega$	100.05	99.9000	100.1000	Pass
200.00 $\Omega$	200.06	199.8000	200.2000	Pass
300.00 $\Omega$	300.13	299.7000	300.3000	Pass
400.00 $\Omega$	400.23	399.6000	400.4000	Pass
500.00 $\Omega$	500.27	499.5000	500.5000	Pass
600.00 $\Omega$	600.31	599.4000	600.6000	Pass
700.00 $\Omega$	700.32	699.3000	700.7000	Pass
800.00 $\Omega$	800.42	799.2000	800.8000	Pass
900.00 $\Omega$	900.46	899.1000	900.9000	Pass



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EA 107

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## CALIBRATION CERTIFICATE

<b>CERTIFICATE NUMBER</b>	: CTP 2035-09	<b>JOB NUMBER</b>	: CTJ 1777-09
<b>DATE RECEIVED</b>	: 24-Feb-09	<b>ISSUE DATE</b>	: 26-Feb-09

<b>Instrument</b>	: ADVANCED PRESSURE CALIBRATOR	<b>Ambient Temperature</b>	: 21 ± 2 ° C
<b>Manufacturer</b>	: AMETEK	<b>Relative Humidity</b>	: 55 ± 10 % R. H.
<b>Model No.</b>	: APC200 CINDG	<b>Date Calibrated</b>	: 26-Feb-09
<b>Part No.</b>	: ---	<b>Recommended Due Date</b>	: 26-Feb-10
<b>Serial No.</b>	: 8638305		
<b>Customer</b>	: <b>Invensys Process Systems (S) Pte Ltd</b> 15, Changi Business Park Central 1 Singapore 486057	<b>Range</b>	: -1000 ~ 14000mbar
		<b>( Tag No. )</b>	: ---
		<b>Page</b>	: 1 of 2
		<b>Status</b>	: As Found

The described instrument has been calibrated at **Caltex** Laboratory under the ambient conditions stated above.

**Caltex** organisation and practices are in compliance with **ISO/IEC 17025**. The Quality System is in accordance with the **Quality Standard ISO 9001:2000**.

The reference measurement standards used are traceable to **(NMC)** Singapore and National Physical Laboratory **(NPL)**, UK and National Institute of Standards and Technology **(NIST)**, USA or other recognised National or International Standards Laboratories.

### METHOD OF CALIBRATION

- The calibration method was carried out by In-house Technical Calibration Procedure CTTM-M03 & M07:2007, as a guide.

### REFERENCE STANDARD(S) USED FOR CALIBRATION

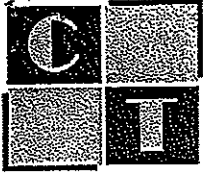
<u>INSTRUMENT</u>	<u>SERIAL NO</u>
1. Pneumatic Pressure Calibrator	61013299
2. Gas Deadweight tester	27929

### RESULTS OF CALIBRATION

- The results of calibration are given on the attached calibration data sheet(s).
- The expanded uncertainty of measurement associated with the calibration is ± 0.289% of reading estimated at a confidence level of approximately 95 % with a coverage factor of K=2.
- The user should determine the suitability of the instrument for its intended use.

  
**S.Prem**  
Calibrated by

  
**Michael**  
Approved by



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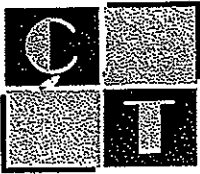
## CALIBRATION CERTIFICATE

CERTIFICATE NUMBER : CTP 2035-09  
ISSUED DATE : 26-Feb-09

JOB NUMBER : CTJ 1777-09  
PAGE : 2 of 2

Applied Actual Value ( mbar )	Mean Instrument Reading ( mbar )			DESCENDING		
	Before Adj	ASCENDING After Adj	Error	Before Adj	After adj	Error
-500.0	-498	---	2.0	-499	---	1.0
-1000.0	-997	---	3.0	-997	---	3.0
0.0	0	---	0.0	0	---	0.0
4813.0	4813	---	0.0	4814	---	1.0
9997.0	9996	---	-1.0	9997	---	0.0
13751.0	13750	---	-1.0	13750	---	-1.0

Remark : Accuracy of the instrument is within  $\pm 0.05\%$  of full scale.



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## CALIBRATION CERTIFICATE

**CERTIFICATE NUMBER** : CE 1311-09      **JOB NUMBER** : CTJ.2644-09  
**DATE RECEIVED** : 15-Apr-09      **ISSUE DATE** : 21-Apr-09

<b>Instrument</b> : mA CALIBRATOR	<b>Ambient Temperature</b> : 21 ± 2 °C
<b>Manufacturer</b> : JF INDUSTRY	<b>Relative Humidity</b> : 55 ± 10 % r.h.
<b>Model No.</b> : mA CAL	<b>Date Calibrated</b> : 21-Apr-09
<b>Serial No.</b> : 530087-04497	<b>Recommended Due Date</b> : 21-Apr-10
<b>Customer</b> : Invensys Process Systems (S) Pte Ltd 15, Changi Business Park Central 1 Singapore 486057	<b>Range</b> : --- ( Tag No. ) : --- <b>Page</b> : 1 of 3 <b>Status</b> : As Found

The described instrument has been calibrated at Caltek Laboratory under the ambient conditions stated above.

Caltek organisation and practices are in compliance with ISO/IEC 17025. The Quality System is in accordance with the Quality Standard ISO 9001:2000.

The reference measurement standards used are traceable to (NMC), Singapore and National Physical Laboratory (NPL), UK and National Institute of Standards and Technology (NIST), USA or other recognised National or International Standards Laboratories.

### METHOD OF CALIBRATION

- The calibration method was carried out by In-house Technical Calibration Procedure CT-E01 & E06:2007 as a guide.

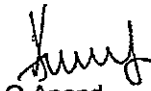
### REFERENCE STANDARD(S) USED FOR CALIBRATION

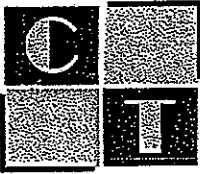
<u>INSTRUMENT</u>	<u>S/N</u>
1. Multifunction Calibrator	8895020
2. Digital Precision Multimeter	3146A30845

### RESULTS OF CALIBRATION

- The results of calibration are given on the attached calibration data sheet(s).
- The expanded uncertainty of measurement associated with the calibration is estimated at a confidence level of approximately 95% with a coverage factor of  $k = 2$ .
- The user should determine the suitability of the instrument for its intended use.

  
 O.M. Yasir  
 Calibration Officer

  
 G. Anand  
 Approved by



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## CALIBRATION CERTIFICATE

CERTIFICATE NUMBER : CE 1311-09  
ISSUED DATE : 21-Apr-09

JOB NUMBER : CTJ 1258-03  
PAGE : 2 of 3

Function Test	Instrument Reading	Low Limit	High Limit	Remark / Status
---------------	--------------------	-----------	------------	-----------------

### MEASURE MODE

#### DC VOLTAGE TEST

1.000 V	1.0	0.5	1.5	Pass
5.000 V	5.0	4.5	5.5	Pass
10.000 V	10.0	9.5	10.5	Pass
20.000 V	20.0	19.5	20.5	Pass
30.000 V	30.0	29.5	30.5	Pass
40.000 V	40.0	39.5	40.5	Pass

#### DC CURRENT TEST

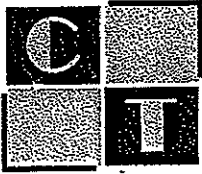
4.000 mA	3.999	3.988	4.012	Pass
8.000 mA	7.999	7.988	8.012	Pass
12.000 mA	11.998	11.988	12.012	Pass
16.000 mA	15.998	15.988	16.012	Pass
20.000 mA	19.998	19.988	29.012	Pass

### SOURCE MODE

#### DC CURRENT TEST

4.0048 mA	4.00	3.988	4.012	Pass
8.0072 mA	8.00	7.988	8.012	Pass
12.0038 mA	12.00	11.988	12.012	Pass
16.0065 mA	16.00	15.988	16.012	Pass
20.0082 mA	20.00	19.988	29.012	Pass





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## CALIBRATION CERTIFICATE

**CERTIFICATE NUMBER :** CE 1311-09  
**ISSUED DATE :** 21-Apr-09

**JOB NUMBER :** CTJ 1258-03  
**PAGE :** 3 of 3

Function Test	Instrument Reading	Low Limit	High Limit	Remark / Status
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FUNCTION TEST	RANGE	EXPANDED UNCERTAINTY
<b>MEASUREMENT MODE</b> DC V	0 ~ 40V	± 0.12% of reading
DC A	0 ~ 20 mA	± 0.075% of reading
<b>SOURCE MODE</b> DC A	0 ~ 20 mA	± 0.12% of reading