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SPEEDING UP THE ISSUE OF FINAL EVALUATION REPORTS

We are constantly striving to reduce the time taken to produce evaluation reports. This involves very tight scheduling and we have allowed four weeks for consideration of draft reports. Unless comments are received within that time it may not be possible to include them in the final printed version.

May we please have your written comments by 12 MAY 1997

Your cooperation in this respect would be appreciated.

Sira Test & Certification Ltd

Report E1769 S 97 (draft)

April 1997

**EVALUATION OF STEWART BUCHANAN PRESSURE GAUGES  
MODELS 36787829 AND 36787853**

Evaluated by Sira Test & Certification Ltd  
on behalf of SIREP International Instrument Users' Association

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**SIRA TEST & CERTIFICATION LTD**

**This is a draft report and is subject to amendment. The manufacturer has not yet had the opportunity of adding his comments.**

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**PRESSURE GAUGES  
MODELS 36787829 and 36787853**

Authors: M A Gibbens  
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Evaluated by Sira Test & Certification Ltd (ST&C) on behalf of  
SIREP International Instrument Users' Association

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## **1 INTRODUCTION**

This report describes the evaluation of two pressure gauges, models 36787829 and 36787853 manufactured in the UK by Stewart Buchanan Gauges Ltd. The gauges were standard production instruments and were supplied by BP International Limited.

The instruments were evaluated to a test programme drawn up by Sira Test & Certification Ltd based on BS 1780, IEC 68-2-30 and BS EN 60068-2-52 and agreed with SIREP.

The instruments measure gauge pressure by converting the deflection of a bourdon tube into pointer movement on a graduated scale.

The manufacturer's specified accuracy is  $\pm 1\%$  for points above 10% and below 90% of full scale, outside these limits accuracy is  $\pm 1.5\%$ .

The gauges have nominal dial diameters of 100 mm and measure pressure in the ranges 0 to 4 bar (model 36787829) and 0 to 100 bar (model 36787853).

The instruments were delivered on the 29 November 1996.

The instruments were evaluated in conjunction with 8 other pressure gauges over a period of 3 months from 2 January 1997 to 26 March 1997. The other gauges are the subjects of SIREP-WIB-EXERA Reports E 1765, E 1766, E 1767, E 1768 and C 1770.

## 2 MAJOR FINDINGS AND COMMENTS

These findings are summarised below for ready reference and to give an overview of the evaluation. For a complete assessment of the instruments the report must be read and considered as a whole.

### 2.1 Instrument performance

All errors and changes are indicated as falling within various arbitrary bands and compared with the manufacturer's specification as follows:

- ✓ within the manufacturer's specification
- x outside the manufacturer's specification
- no manufacturer's specification

#### 2.1.1 0 to 4 bar gauge

All tests were carried out on gauge serial number 15908/2.

Test	Results expressed as error % span					Other results	Manufacturer's specification and (BS specification)
	≤0.5	≤1.0	≤1.5	≤2.0	≤2.5		
<b>ACCURACY, as received</b> maximum error maximum repeatability	■	✓					±1 % between 10 % and 90 % span, ±1.5 % over rest of the scale
<b>HYSTERESIS</b> hysteresis at 50 % span	■						
<b>OVERLOAD</b> maximum change in indication		■					(BS specification +25 % span)
<b>TEMPERATURE</b> maximum change in indication				■			
<b>HUMIDITY</b> maximum change in indication		■				no corrosion	
<b>CREEP STABILITY</b> maximum change in indication		■					
<b>VIBRATION</b> maximum change in indication		■					
<b>BLOW OUT RELEASE</b>						correct operation of blow out protection observed	

**2.1.2 0 to 100 bar gauge**

All tests were carried out on gauge serial number 07703/7.

Test	Results expressed as error % span					Other results	Manufacturer's specification and (BS specification)
	≤0.5	≤1.0	≤1.5	≤2.0	≤2.5		
<b>ACCURACY</b> maximum error maximum repeatability		✓ ■					±1 % between 10 % and 90 % span, ±1.5 % over rest of the scale
<b>HYSTERESIS</b> hysteresis at 50 % span	■						
<b>OVERLOAD</b> maximum change in indication		■					(BS specification +25 % span)
<b>TEMPERATURE</b> maximum change in indication				■			
<b>CREEP STABILITY</b> maximum change in indication		■					
<b>SALT MIST</b> maximum change in indication		■				no corrosion	
<b>VIBRATION</b> maximum change in indication		■					
<b>BLOW OUT RELEASE</b>						correct operation of blow out protection observed	

## **2.2 Comments on construction, use and packaging**

### **Construction and use**

The instruments appear to be well made and are easy to read.

### **Packaging**

The instruments were received packed in a small close fitting cardboard box.

## **2.3 Comments on documentation**

No documentation was supplied with the gauges. The gauges were supplied by BP International Ltd from one of its world-wide sites, the documentation received may not be typical of that usually supplied with the gauge.

## **2.4 Manufacturer's comments (not in draft report)**

### 3 TEST RESULTS

Unless otherwise stated, tests were performed at  $20 \pm 2^\circ\text{C}$  and relative humidity  $< 60\%$ . Dry air was used as the pressurising medium for the 0 to 4 bar gauge and filtered R10 Mineral Oil was used as the pressurising medium for the 0 to 100 bar gauge. The measurement uncertainty was 0.1 % span. For the 0 to 4 bar gauge the scale markings were 5.0 % span and the gauge was read to 1.0 % span. For the 0 to 100 bar gauge the scale markings were 5.0 % span and the gauge was read to 1.0 % span. All errors are expressed in % span.

#### 3.1 Results' summary

Test	Test Results		Manufacturer's specification/Report ref (and BS specification)
	0 to 4 bar gauge	0 to 100 bar gauge	
<b>ACCURACY</b> maximum error	$\pm 1.0\%$	$-1.0\%$	$\pm 1\%$ between 10 % and 90 % span, $\pm 1.5\%$ over rest of the scale Figs 2 and 3
<b>HYSTERESIS</b> hysteresis at 50 % span	no hysteresis	no hysteresis	not specified
<b>OVERLOAD</b> 125 % span applied for 1 min after 5 min recovery  maximum change in indication	$+1.0\%$	$-1.0\%$	(BS specification $+25\%$ span)
<b>TEMPERATURE VARIATIONS</b> $-20^\circ\text{C}$ to $50^\circ\text{C}$  maximum change in indication	$-2.0\%$ at $-20^\circ\text{C}$	$-2.0\%$ at $-20^\circ\text{C}$	not specified  Section 3.2
<b>HUMIDITY CYCLING</b> after 6 cycles at a severity of $55^\circ\text{C}$ relative humidity $> 95\%$  maximum change in indication visual inspection	$\pm 1.0\%$ no deterioration		not specified
<b>CREEP STABILITY</b> after 1000 cycles of operation between 10 % and 75 % span  maximum change in indication	$+1.0\%$	$\pm 1.0\%$	not specified
<b>SALT MIST</b> maximum change in indication visual inspection		$+1.0\%$ no corrosion	not specified

Test	Test Results		Manufacturer's specification/Report ref (and BS specification)
	0 to 4 bar gauge	0 to 100 bar gauge	
<b>VIBRATION</b> 10 to 150 Hz at 5 m/s <sup>2</sup> (0.5 g)			not specified
horizontal vibration (parallel to plane of dial)	frequency Hz 30 to 40	maximum change in indication 1.25 %	no effect
horizontal vibration (perpendicular to plane of dial)	frequency Hz 114 to 130	maximum change in indication face glass resonance	no effect
vertical vibration	frequency Hz 10 to 45 25 95 to 111	maximum change in indication 1.25 % 5 % 2.5 %	no effect
maximum change in indication after vibration	+1.0 %		-1.0 %
<b>BLOW OUT RELEASE</b> 125 % span applied instantaneously to gauge casing with bourdon tube cut through	blast effect away from the front of the gauge		blast effect away from the front of the gauge

### 3.2 Temperature effects

#### 0 to 4 bar gauge

Temperature °C	Average * gauge reading bar							Maximum hysteresis % span
	0 % span	20 %	40 %	60 %	80 %	95 %	100 %	
+20	0	0.80	1.56	2.40	3.24	3.88	>4.00	0
+50	0	0.80	1.60	2.42	3.24	3.88	>4.00	1.0
+20	0	0.78	1.60	2.40	3.24	3.84	>4.00	1.0
0	0	0.80	1.58	2.38	3.20	3.84	>4.00	1.0
-20	0	0.76	1.56	2.36	3.16	-	4.00	0
+20	0	0.80	1.60	2.40	3.24	3.84	>4.00	0

#### 0 to 100 bar gauge

Temperature °C	Average * gauge reading bar							Maximum hysteresis % span
	0 % span	20 %	40 %	60 %	80 %	95 %	100 %	
+20	0	20	40	60	80	-	100	0
+50	0	20	40	60	80	96	>100	0
+20	0	20	40	60	80	-	100	0
0	0	20	40	60	79	-	99	0
-20	0	20	39	58	78	-	98	0
+20	0	20	40	60	80	-	100	0

\* Average of rising and falling gauge reading.

Fig 2 Accuracy test, 0 to 4 bar gauge

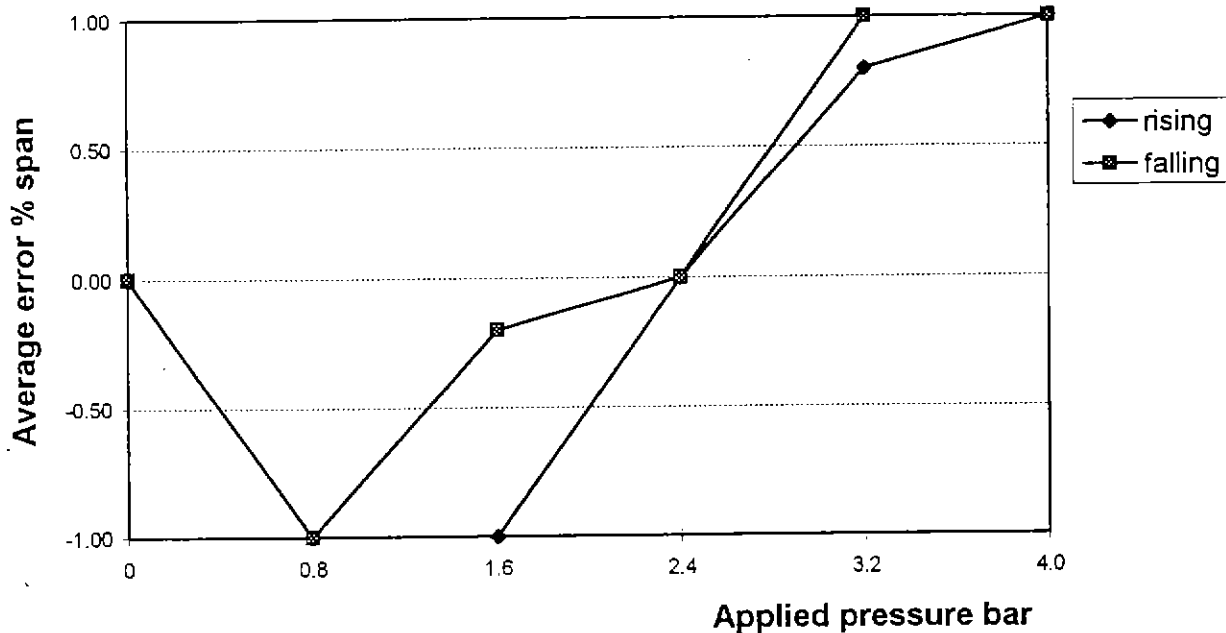
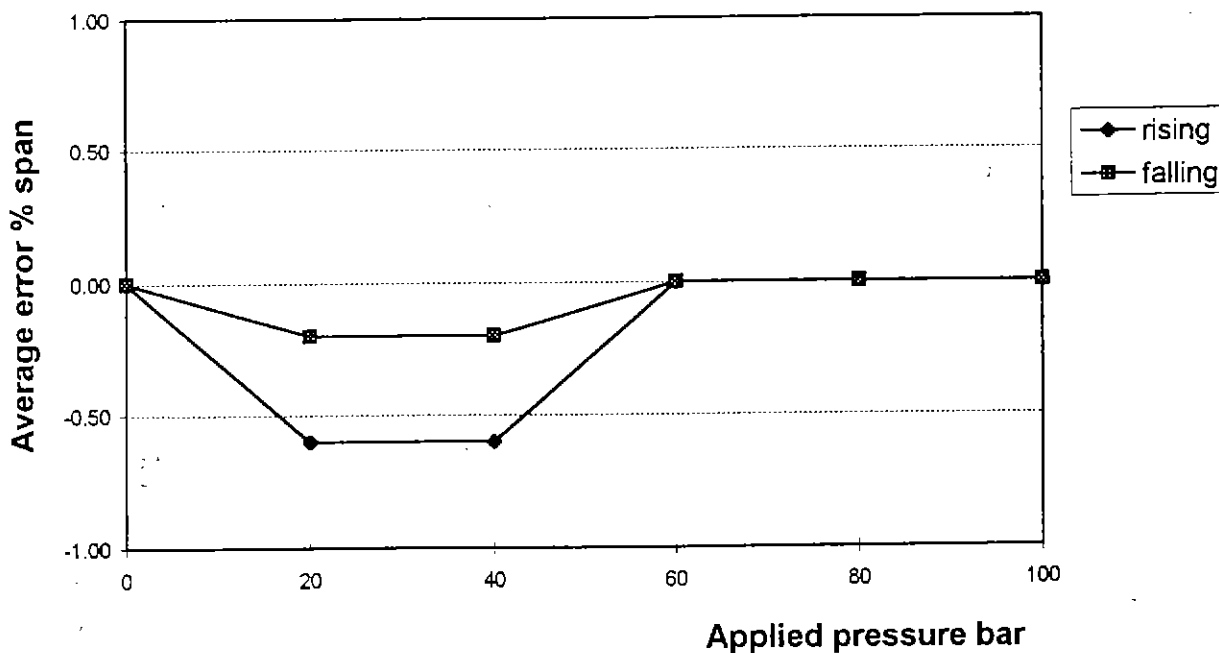
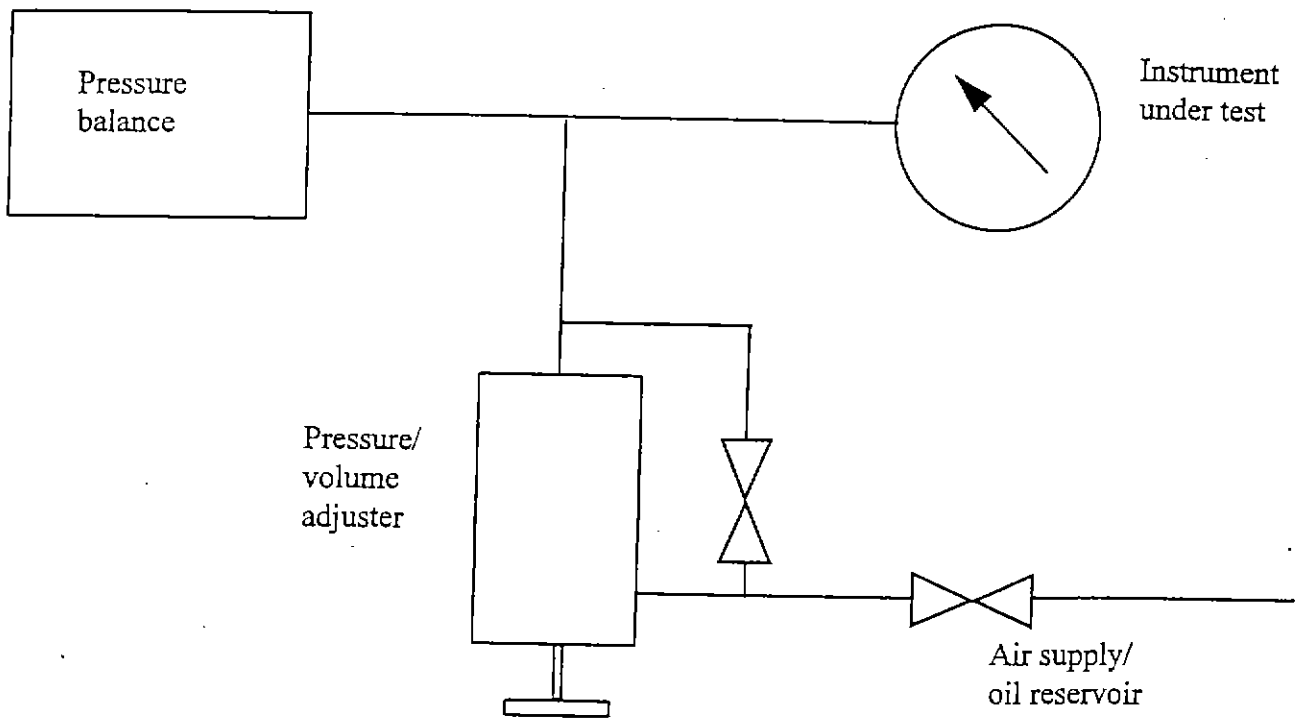


Fig 3 Accuracy test, 0 to 100 bar gauge





**Fig 4 Basic Test Arrangement**

#### 4 MANUFACTURER'S DATA

##### Instrument specification and other details provided by the manufacturer

Manufacturer	Stewart Buchanan Gauges Ltd Burnside Industrial Estate Kilsyth Glasgow G65 9JX  Tel: 01236 821533 Fax: 01236 824090
Instruments	Bourdon tube pressure gauges
Models and Pressure ranges	36787829, 0 to 4 bar 36787853, 0 to 100 bar
Serial Numbers	15908/2 and 07703/7
Pressure ranges	0 to 4 bar : 15908/2 0 to 100 bar : 07703/7
Nominal dial diameter	100 mm
Scale	concentric 270°, white with black markings
Mounting	direct by bottom connection
Connection	½ NPT
Case	Stainless steel

## 5 OPERATING PRINCIPLE AND CONSTRUCTION

### 5.1 Operating principle

The pressure sensing element is a bourdon tube connected by an adjustable linkage to the pointer spindle via a quadrant and pinion gear assembly.

### 5.2 Mechanical construction

The gauge has a round case of stainless steel. The bourdon tube and process connection are monel. The gauge has a blow out back and the face is laminated glass secured to the case by a stainless steel bezel. The bourdon tube support and connection constitute a unit fixed radially to the case.

## 6 TEST METHODS AND REFERENCES

### 6.1 Test methods

The basic test arrangement is shown in Figure 4.

The estimated applied pressure measurement uncertainty was  $\pm 0.1$  % span. The 0 to 4 bar gauge had scale divisions of 0.2 bar (5 % span) and readings were taken to 0.04 bar (1 % span). The 0 to 100 bar gauge had scale divisions of 5 bar (5 % span) and readings were taken to 1 bar (1 % span).

Unless otherwise stated, all tests were carried out under the following reference conditions:

Laboratory temperatures	:	20 $\pm$ 2°C
Mounting position	:	dial in vertical plane
Process fluid	:	
0 to 4 bar	:	filtered dry air
0 to 100 bar	:	R10 mineral oil

### Accuracy

The gauge was subjected to a pressure equal to the maximum scale value. Then, without recalibration or adjustment, a six point (20 % full scale intervals) calibration was carried out for rising and falling pressures.

### Hysteresis

The test pressure was increased slowly from 0 to 50 % span and the gauge reading noted. The test pressure was further increased to 100 % span and then slowly decreased to 50 % span and the gauge reading again noted. No tapping or external vibration were applied during the test.

### Overload

A pressure equal to 125 % span was applied to the gauge for a period of 1 min. After 5 min recovery time, with the pressure connection open to atmospheric pressure, the gauge calibration was checked at six points (20 % full scale intervals).

## Ambient temperature variations

The following temperature cycle was applied to the gauge:

Standard conditions	+20°C
Dry heat	+50°C
Standard conditions	+20°C
Cold exposure	0°C
Cold exposure	-20°C
Standard conditions	+20°C

At each ambient temperature measurements were taken at intervals of 20 % full scale pressure with rising and falling pressures. At least 6 h was allowed for stabilisation at each temperature.

## Humidity cycling (carried out on the 0 to 4 bar gauge)

The gauge was subjected to six cycles of the humidity cycling test described in IEC 68-2-30:1980, variant 2, severity +55°C.

Each cycle comprised the following.

The temperature was raised from +25 ±3°C to +55°C in 2.5 to 3.5 h during which time the relative humidity was not less than 95%, except during the last 15 min when it was not less than 90 %. The temperature remained at 55°C until 12 h ±30 mins from the start of the cycle. During this period the relative humidity was 93 ±3% except for the first and last 15 min when it was between 90 % and 100 %.

The temperature was lowered to 25 ±3°C within 3 h to 6 h. During this time the relative humidity was not less than 80 %. The temperature was then maintained at 25 ± 3°C with a relative humidity of not less than 95% to complete the 24 h cycle.

After the six cycles the ambient conditions were returned to +20°C, 50 % rh, the gauge was then inspected for corrosion and a six point calibration was carried out.

## Creep stability

The gauge was operated 1000 times between 10 % and 75 % full scale reading. The pressure was maintained for at least 5 minutes at 10 % and 75 % full scale readings on each cycle of operation. A six point calibration was carried out before and after the test.

## Salt mist (carried out on the 0 to 100 bar gauge)

The salt mist test described in BS EN 60068-2-52:1996 was carried out on the gauge. The severity was severity 1. The gauge was exposed to the salt mist for a period of 2 h with the temperature between 15°C and 35°C and then stored at a temperature of 40 ±2°C and relative humidity between 90 % and 95 %. Four spraying periods were carried out with a storage of 7 days after each. After the test the gauge was cleaned in de-ionised water, dried for one hour at 55°C and then inspected for corrosion and a six point calibration carried out.

## Vibration

The gauge was vibrated over the frequency range 10 to 150 Hz at 5 m/s<sup>2</sup> (0.5 g) peak acceleration. Vibration was applied in the vertical and in two horizontal directions in turn. A resonance search was carried out with a 50% full scale pressure applied to the gauge. The gauge reading was monitored throughout the test and a six point calibration was carried out before and after the test.

## Blow out release test

Correct operation of gauge blow out protection was tested by applying a pneumatic pressure of 125 % span instantaneously to the inside of the gauge casing with its bourdon tube cut through to enable the pressure to be applied directly into the gauge casing. Correct operation of gauge blow out protection to be checked.

### 6.2 References

**BS 1780 : 1985 (1992)** : Specification for Bourdon tube pressure and vacuum gauges.

**IEC 68-2-30 : 1980** : Basic environmental testing procedures, Test Db and guidance : damp heat, cyclic (12 + 12 hour cycle)

**BS EN 60068-2-52 : 1996** : Environmental testing, Test Kb. Salt mist cyclic (sodium chloride solution).

**IEC 902 : 1987** : Industrial - process measurement and control terms and definitions.

**BS 5233 : 1986** : Glossary of terms used in metrology.

**IEC draft standard, reference 1 (IEV 301, 302, 303)(Sec.) 1386** : International vocabulary of basic and general terms in metrology.

### Manufacturer's literature

### 6.3 Definitions

**Error (IEC 902)** : The algebraic difference between the measured value and the true value of the measured variable.

**Average error** : The arithmetic mean of the errors at each point of measurement, for rising and falling inputs separately.

**Repeatability (IEC draft standard, reference 1 (IEV 301, 302, 303)(Sec.) 1386)**: The ability of a measuring instrument to provide closely similar indications for repeated applications of the same measurand under the same conditions of measurement. (In this report repeatability is expressed as one standard deviation of the errors from the average error at each point of measurement, for rising and falling inputs separately).

**Uncertainty of measurement (BS 5233)** : An estimate characterising the range of values within which the true value of a measurand lies. (The uncertainties quoted are for a confidence probability of not less than 95 %).

**Hysteresis error (IEC 902)** : The maximum deviation between the two calibration curves of the measured variable as obtained by an upscale going traverse and a downscale going traverse over the full range and subtracting the value of the dead band.

**Range (IEC 902)** : The region of the values between the lower and upper limits of the quantity under consideration.

**Span (IEC 902)** : The algebraic difference between the upper and lower limit values of a given range.