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Procedures for the Validation of the Hydraulic Control System of Sub Surface Safety Valves at HP/HT Conditions

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Reports in the OTO series can be obtained from Research Strategy Unit, Bootle, Merseyside, L20 3DL
Fax: 0151 951 3098

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1. INTRODUCTION

In the offshore oil and gas industry, the surface controlled subsurface safety valve (SCSSV) - also called the down hole safety valve (DHSV) - is considered to be one of the primary safety barriers in a producing well. The valve is set in the well completion string at a pre-determined depth below the seabed. Current operator philosophies favour the use of a hydraulically operated actuator linked to the surface by a small bore line to control its opening/closure. The SCSSV, the actuator and the control fluid are exposed to the downhole well conditions.

Prior to the development of HP/HT reservoirs in the North Sea the operating experience with these hydraulic systems was satisfactory. The HP/HT conditions i.e, temperatures between 150 and 200°C (300 to 400°F) and pressures of 680 to 1380 bar (10,000 to 20,000 psi) have led to the need to verify the operability of the currently available systems.

A collaborative research project was carried out to do a broad based investigation of both control fluids and hydraulic control systems. This has included the construction of a test facility to simulate the downhole control system under HP/HT conditions. Tests with representative control fluids and safety valve hydraulic actuators have highlighted a number of potential problem areas.

The project has resulted in test procedures which could help to select appropriate systems for HP/HT applications and to validate existing systems. It is hoped that eventually these procedures will find their way into the appropriate ISO standards. HSE have agreed to publish this material at this time as an OTO report as a preliminary vehicle to bring the results of this safety related work into the public domain at an early stage.

2. BACKGROUND

2.1 Problem Areas

The potential problems identified that could influence the reliability of the control system include:

- Leakage of control fluid - leading eventually to inability to maintain sufficient pressure to open the control valve.
- Contamination of the control fluid by: wellbore products, seawater or completion fluid.
- Change of fluid properties - including changes of viscosity, corrosion resistance, lubricity etc. may cause either short or long term problems with the function of the system.
- Fluids used during commissioning and preservation may contaminate the control fluid.
- Fluid degradation products - these are commonly sludge or particulate. The possibility of the creation of sufficient debris to plug the control line, hence inhibiting valve operation is a major concern.
- Combined effects of pressure and temperature, causing accelerated degradation compared with individual testing of pressure and temperature.
- Pressure cycling - may effect fluid properties.
- Temperature cycling - degraded fluid may have a high viscosity at sea-bed temperature.

2.2 System Testing Requirements

The test facility has been designed to represent the key factors of the downhole control system of a well completion including:

- Representative downhole volume of test fluid
- Vertical orientation of the control fluid test volume to investigate potential plugging.
- Test volume at working pressure and temperature.
- Hydraulic actuator duty cycle including number of cycles and representative periods of "valve open" condition.
- Representative hydraulic line resistance to replicate opening and closing times.
- Replication of both downhole and seabed conditions to provide temperature cycling during actuator operations.

- Representative fluid and pressure conditions across the hydraulic actuator.

- Capability to check for leakage across actuator seals at low and high control pressures.

A test facility to this design can investigate all the potential problem areas identified above, in one combined test. In this way the absence or presence or any interacting factors will be verified thus providing a high degree of confidence in the test fluids and valve actuator components that meet the test criteria.

2.3 Screening Tests

Testing on such a facility is both time consuming (3 month test period) and relatively costly due to the facilities involved.

Prior to commissioning such a test the customer should satisfy themselves that both the test fluid and the SCSSV components have completed screening procedures to demonstrate their potential suitability for the anticipated operating conditions.

Suitable screening procedures are discussed in Appendices 3 and 5.

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3. CONTROL SYSTEM VALIDATION PROCEDURE

3.1 Scope

This section describes the technical specification and operating procedure of a facility for the validation testing of surface controlled sub surface safety valve (SCSSV) actuators and hydraulic control fluid systems for HP/HT applications. The safety valve actuator, hydraulic control line and hydraulic media are tested simultaneously, enabling the performance of the safety valve control system as a whole to be studied.

3.2 Test Facility Specification

The facility will be described in terms of several main modules:-

i) Safety Valve Test Module
ii) Main Hydraulic Control Line
iii) Chilled Hydraulic Control Line
iv) Fluid Pressure Supply

All parts of the test facility that come into contact with control fluid are to be manufactured from corrosion resistant materials such as:- stainless steel, nickel based alloys (e.g. Hastelloy or Inconel) or titanium.

3.2.1 Safety Valve Test Module

Each test module contains a safety valve actuator to be tested. The control fluid is fed via a port in the top of the module. The well bore fluid is simulated by pressurised Nitrogen gas fed into the bottom cavity via a port at the bottom of the module, Figure 1.

The casing of the module is heated to the required well temperature by heaters fastened to the outside of the casing. The whole module is thermally insulated. Alternatively a complete safety valve may be tested.

3.2.2 Main Hydraulic Control Line

A vertically mounted column, with dimensions of: minimum length 5 m, maximum inside diameter 30 mm, minimum volume 2.5 litres simulates the typical volume of a downhole control line. The bottom of the column tapers down to connect with actual control line minimum length 0.5 m, maximum bore 3.2 mm. The lower end of this control line connects into the top of an actuator test module, see Figure 2. Since the large bore diameter of the column would not have the same hydraulic resistance (pressure drop) as 300 metres of control line, a restriction is to be present at the top of the column. This will comprise a capillary tube, 1 mm bore x 1 m long. Leakage of well bore fluid into the control line or control fluid into the well bore is detected by measuring changes

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in fluid pressure using the leakage isolator valve, see Figure 2. This valve will be positioned such that the "pressure test volume", including actuator and pipework, is less than 100 ml.

3.2.3 Chilled Control Line

In a working safety valve system, the valve is closed by removing the control line fluid pressure. This displaces fluid from the 'hot' section of the control line into the cooler section that can be in contact with sea-water. The reduction in temperature could cause blockage if any high viscosity products become present in the fluid. The facility will replicate this effect, when relevant to the application, by allowing the displaced test fluid to pass through a chilled section of line when fluid is displaced from the top of the column. This will comprise 7 m of control line submerged in a bath of water kept at a constant temperature of 4°C. See Figure 2. (NB Compressibility of hydraulic fluid and expansion of metalwork is such that the displaced volume of fluid is approximately twice the actuator displacement).

3.2.3 Fluid Pressure Supply

The hydraulic system generating the control line pressures is required to operate the valve actuator, up to a maximum rated pressure. The system will permit pressure cycling between rated pressure and the 'closed' control line pressure. The 'closed' control line pressure is the nominal hydrostatic head that the safety valve will experience in practice. A typical pressure is 35 bar (500 psi) but the actual application hydrostatic head will be used. The circuit design and controls will be such that, under normal test conditions, the control line pressure can only be reduced below the 'closed' pressure when test is complete and control line temperature is below 80°C.

3.3 Test Conditions

3.3.1 Test Control Fluid - Test control fluid selected is to satisfy the requirements of a suitable screening procedure (e.g. Appendix 3) at the proposed test temperature. A sample of the fluid is to be retained for later comparison.

3.3.2 Valve Design - As agreed between the valve supplier and the customer/user, see Appendix 5.

3.3.3 Gas Pressure - Maximum anticipated well bore pressure.

3.3.4 Control Line Pressures - As agreed between valve supplier and customer/user.

3.3.5 Temperature - Maximum anticipated operating temperature plus 10°C.

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3.4 Test Procedure

3.4.1 Preparation of Test Actuation Module - Valve test module is to be assembled using only assembly compounds and lubricants as agreed between the control fluid and valve suppliers.

3.4.2 Preparation - Clean and Flush Facility - Test facility to be flushed through using a suitable cleaning fluid selected and as agreed between the valve and control fluid suppliers. Appropriate heating, typically to 80 - 100°C is recommended to ensure residues are dissolved.

3.4.3 Fill with Test-Fluid - The control fluid should be transferred to the test facility from its container via a filter/pump set which will be fitted with a suitably rated filter element to meet the filtration levels required for the tests.

3.4.4 Filter Control Fluid - It is imperative that the fluid is adequately clean prior to fitting the actuator module. The fluid will be circulated throughout the test facility via a suitable filter arrangement until a cleanliness level of NAS6 or better is achieved. A sample will be retained for later comparison.

3.4.5 Fit Actuator - Normal workshop practice of cleanliness for high pressure hydraulic systems will be used. No assembly compounds or lubricants other than those agreed between valve and fluid suppliers will be used.

3.4.6 Heat and Pressurise Facility - Heat and pressurise the test facility to the required temperature and pressure, Sections 3.3.3, 3.3.4 and 3.3.5.

3.4.7 Testing

3.4.7.1 **Cycle the Actuator** - Within 12 hours of achieving test conditions, Section 3.4.6, carry out 50 cycles of the test actuator. Maximum permitted cycling rate: 12 cycles per hour. Record full open, full closed control line pressures for cycles: 1, 10, 20, 30, 50. Record leakage rate: control to gas in open position at cycles 2, 25, 50. Record leakage rate: gas to control in closed position at cycles 2, 25, 50.

3.4.7.2 **Static Period** - The test actuator will be left in its 'open' condition, at test pressures, test temperature, for 4 weeks.

3.4.7.3 **Cycle the Actuator** - 200 cycles of the test actuator, (cumulative total 250). Maximum permitted cycling rate: 12 cycles per hour. Record full open, full closed control line pressures for the first and every 10th cycle. Record leakage rate: control to gas in open position at every 25 cycles. Record leakage rate: gas to control in closed position at every 25 cycles.

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3.4.7.4 **Static Period** - The test actuator will be left, at test pressure, high temperature state, for 4 weeks. (Cumulative total 8 weeks).

3.4.7.5 **Cycle the Actuator** - 200 cycles of the test actuator, (Cumulative total 450). Record full open, full closed control line pressures for the first cycle and subsequently for every 10th cycle. Record leakage rate control to gas in open position at every 25 cycles. Record leakage rate: gas to control in closed position at every 25 cycles.

3.4.7.6 **Static Period** - The test actuator will be left, at test pressure, high temperature state, for 4 weeks. (Cumulative total 12 weeks).

3.4.8 End of Test

3.4.8.1 **Cycle the Actuator** - 200 cycles of the test actuator, (Cumulative total 650). Maximum permitted cycling rate: 12 cycles per hour. Record full open, full closed control line pressures for the first cycle and subsequently for every 10th cycle.

Record leakage rate: control to gas in open position at every 25 cycles. Record leakage rate: gas to control in closed position at every 25 cycles.

3.4.8.2 **Sample Fluid** - Take samples of fluid, volume of each sample to be 30 to 50 ml, in sequence from the top, middle and bottom of the column.

3.4.8.3 **Retain Tested Fluid** - Approximately 2 litres of test fluid is to be saved for analysis. Fluid to be subjected to analysis procedures as per Appendix 3, Part 5.

3.4.8.4 **Remove Test Actuator** - Disassemble module and complete a component detailed inspection report. Report also on signs and type, if any, of debris and any visible plugging. The report format is given at Appendix 2.

3.4.8.5 **Total Test Duration 12 weeks.**

3.4.8.6 **Total Actuator Cycles 650.**

A complete test procedure check list is provided in Appendix 1

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4. ACCEPTANCE CRITERIA

Acceptance criteria will be agreed between the customer and supplier. The following are examples of acceptance criteria based on industry and research experience.

4.1 Successful completion of 650 cycles of the actuator module and 12 weeks exposure to test conditions.

4.2 Throughout the test, the full open control line pressure to be within +/- 10% of the full open pressure recorded for the first cycle.

4.3 Leakage as measured by pressure change at the actuator inlet in the 'pressure test volume':

A) Control to gas in open position - less than 200 psi in 10 sec.
B) Gas to control in closed position - less than 200 psi in 10 sec.

4.4 Satisfactory strip down component detail inspection report. (For an example strip down report form - see Appendix 2:

4.5 The particulate level in the used fluid samples should be measured as detailed in Appendix 3, **Part 5.3**. For reliable operation fluids complying with Grades A and B have been found to be successful.

TEST RIG FIGURES

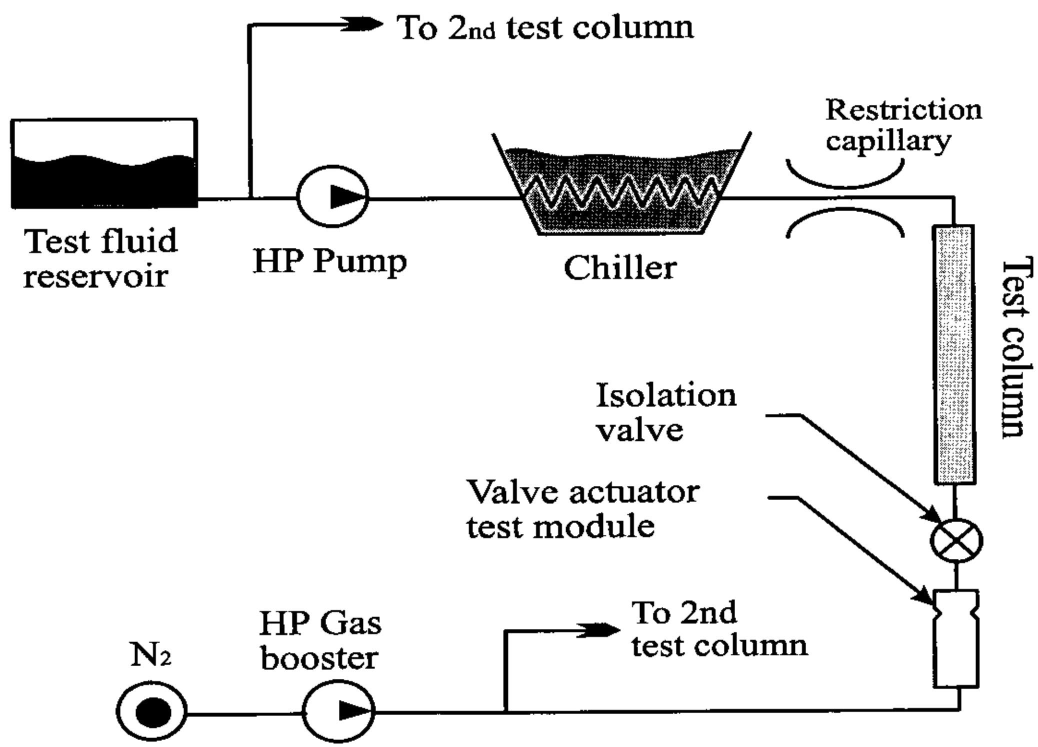

Figure 1 - Test Rig Schematic

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TEST RIG FIGURES

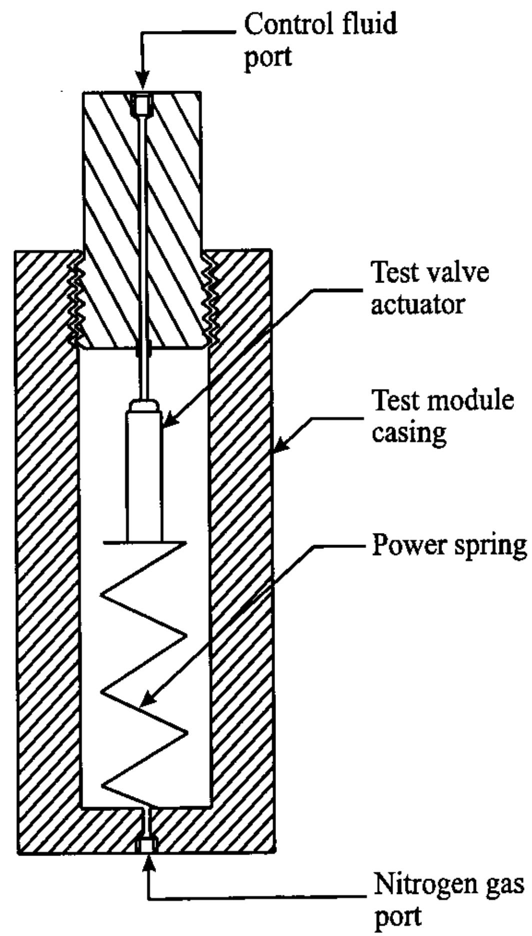

Figure 2 - Valve Actuator Test Module

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APPENDIX 1

SUB-SURFACE SAFETY CONTROL SYSTEM TEST FACILITY

TEST PROCEDURE CHECK-LIST

Test Nos_______	Old Fluid Code_________	New Fluid Code________
Column Nos________	Old Valve Code_________	New Valve Code________

PREPARATION

Initial when completed

____	Flush facility	Fill reservoir with agreed cleaning fluid. Connect clean-up filter to column. Open hand-valve. Start hydraulic pump. Leave for sufficient time to rinse around facility, operating valves periodically. Drain cleaning fluid.
____	**Change cleaning fluid. 1st. Change**	Fill reservoir with agreed cleaning fluid. Heat column to 80 to 100^0 for 4 hours. Drain cleaning fluid.
____	**Change cleaning fluid. 2nd. Change**	Fill reservoir with agreed cleaning fluid. Heat column to 80 to 100^0 for 4 hours. Drain cleaning fluid.
____	**Fill with Test-Fluid**	Fill reservoir with 10 litres of new test fluid (make sure that the drain valve is closed !). Pump fluid around facility and through clean-up filter, periodically operating valves. Drain fluid and refill reservoir with 16 litres of test fluid. Pump through clean-up filter for minimum of 12 hours. When in low pressure state (500 psi) rinse each sample point by opening it for a few seconds. Take 200 ml sample of new clean fluid.
____	**Fit actuator**	Fit actuator into facility. Connect hydraulic pipe, Nitrogen connection, heater bands and thermocouples.

TESTING - Month ONE (Day 1 to 27)

____	**Start test** **Start date.............**	Raise to low pressure state. Heat to test temperature in steps, such that the temperature does not overshoot'. Leave in high pressure state for 12 hours.
____	**Cycling**	Do 50 cycles of the actuator, taking 'pressure' graphs at 1; 10, 20, 30, 40 and 50 cycles. Leak-check[1]. Maximum permitted cycling rate: 12 cycles per hour.
_____	**Soak** **Start-date.............**	Start 'SOAK' condition (4 weeks).

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TESTING - Month TWO (day 28 to 55)

_____	**Cycling**	Do 200 cycles of the actuator, taking 'pressure' graphs for the first and subsequently every 10 cycles. Leak-check[1] actuator every 25 cycles.
_____	**Soak start-date..........**	Start 'SOAK' condition (4 weeks).

TESTING - Month THREE (day 56 to 83)

_____	**Cycling**	Do 200 cycles of the actuator, taking 'pressure' graphs for the first and subsequently every 10 cycles. Leak-check[2] actuator every 25 cycles. Maximum permitted cycling rate: 12 cycles per hour.
_____	**Soak start-date........**	Start 'SOAK' condition (4 weeks).

END OF TEST (day 84)

_____	**Cycling**	Do 200 cycles of the actuator, taking 'pressure' graphs for the first and subsequently every 10 cycles. Leak-check[1] actuator every 25 cycles. Maximum permitted cycling rate: 12 cycles per hour.
_____	**Sample fluid**	Take samples of fluid from top, middle, and bottom sample points in that order.
_____	**Shut down facility**	Leave facility to cool down. Depressurise when cool.
_____	**Empty old fluid**	Close isolating valve. Remove old actuator module and cap both ends to retain fluid. Place clean container under isolating valve. Open top column sample valve. Open isolating valve to fill container with column fluid (2 litres). Save fluid.
_____	**Clean Column**	Remove column top end-cap. Close isolating valve. Remove top and bottom column fluid thermocouple (plug bottom hole). Fill column with agreed cleaning fluid.

[1]Leak-check by closing isolating valve and turning off hydraulic pump.

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APPENDIX 2

ACTUATOR INSPECTION REPORT

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DESCRIPTION		
PART NO:	SERIAL NO:	
METALLURGY:	SEAL TYPE / MATERIAL:	PISTON DIA.
TEST NO:	START DATE:	COMPLETION DATE:
FLUID TYPE:		
TEST TEMPERATURE:		
TEST PRESSURE - GAS: CONTROL LINE PRESSURE -VALVE OPEN: CONTROL LINE PRESSURE - VALVE CLOSED:		
650 CYCLE TEST COMPLETED	YES/NO	
IF 'NO' PLEASE INDICATE REASON TEST WAS HALTED:		

DIMENSIONAL INSPECTIONS

Note: The same equipment, methods and techniques are to be used for both pre-assembly and strip-down inspections and should be subject to agreement between supplier\manufacturer and client. A format for reporting of the same should also be agreed.

ASSEMBLY

PISTON COMPONENTS

DIMENSIONS : ALL WITHIN SPECIFIED TOLERANCES YES/NO

IF NO DETAILS:

CYLINDER COMPONENTS

DIMENSIONS : ALL WITHIN SPECIFIED TOLERANCES YES/NO

IF NO DETAILS:

DISASSEMBLY

Note: On disassembly of actuator photograph all components and include in strip down report

1. PISTON COMPONENTS - VISUAL INSPECTION

EVIDENCE OF:

WEAR	YES/NO	DEFORMATION	YES/NO
CRACKING	YES/NO	SOLID DEPOSITS	YES/NO
PITTING	YES/NO	COATING REMOVED	YES/NO
GALLING	YES/NO	DISCOLOURATION	YES/NO

DETAILS:

2. POST TEST-DIMENSIONAL INSPECTION

DIMENSIONS : ALL WITHIN SPECIFIED TOLERANCES YES/NO

IF NO GIVE DETAILS:

3. CYLINDER BORE - VISUAL INSPECTION

EVIDENCE OF:

WEAR	YES/NO	DEFORMATION	YES/NO
CRACKING	YES/NO	SOLID DEPOSITS	YES/NO
PITTING	YES/NO	COATING REMOVED	YES/NO
GALLING	YES/NO	DISCOLOURATION	YES/NO

DETAILS:

4. ACTUATOR CONNECTOR THREADS / METAL SEALS - VISUAL INSPECTION

EVIDENCE OF:

DAMAGE	YES/NO
DEFORMATION	YES/NO
SOLID DEPOSITS	YES/NO
DISCOLOURATION	YES/NO

5. GENERAL CONDITION OF TEST ACTUATOR (AFTER STRIP DOWN)

DETAILS:

6. GENERAL CONDITION OF ANY FLUID REMAINING IN ACTUATOR:

SAMPLE IDENTIFICATION No.

DETAILS:

REPORT COMPLETED BY:

DATE:

APPENDIX 3

FLUID STABILITY SCREENING PROCEDURES INCLUDING HP/HT

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1. INTRODUCTION

Fluid stability testing will be carried out according to the procedures, described in **Parts 4 and 5**. In addition for HP/HT applications an additional test can be carried out at the HP/HT conditions. This is detailed in **Part 6** . This test will only be carried out on a fluid which has completed the tests of **Parts 4 and 5** to the satisfaction of the supplier and customer.

2. TEST VESSEL CLEANING PROCEDURE

2.1 Screening vessels should be manufactured in stainless steel, Grade 316, and be suitably designed having a full diameter removable cap so as to permit 'straight through' inspection and cleaning. An example vessel is shown in Fig 1. Prior to filling, each test vessel must be cleaned as per the procedures detailed in Appendix 4.

3. TEST VESSEL CLEANLINESS QUALIFICATION

3.1 Remove the top end cap and fill the Test Vessel with 150 ml of filtered Petroleum spirit (if next test to involve oil-based fluid) or filtered de-ionised water (if next test to involve water-based fluid).

3.2 Seal the Test Vessel with the top end cap and agitate.

3.3 The number of particles in the fluid from the Test Vessel should be counted using an Automatic Particle Counter or by counting particles that are filtered out by a 1.2 micro metres nominal pore size membrane. The number of particles greater than 5 micro meters should not exceed 500 per 100 ml.

3.4 If the number of particles found in **Part 3.3** exceeds 500 per 100 ml, then the Test Vessel should be re-washed in accordance with **Part 3 onwards of the Test Vessel cleaning procedure, Appendix 4.**

4. FLUID AGEING PROCEDURE

Fluid ageing tests will be carried out at the following temperatures:

-10°C, 0°C, 70°C, Maximum operating temperature + 10°C.

4.1 Remove the top end cap and ensure that all fluid used in the rinsing procedure has been drained away from the Test Vessel and that the interior is dry.

4.2 Pour 400 ml +/- 5 ml into the Test Vessel, trying not to let the fluid touch the neck of the vessel. The Test Vessel should now remain in the vertical position until the testing has finished.

4.3 Replace and tighten the top end cap. Weigh and record vessel weight.

4.4 Loosen vent screw B by two turns, Fig 1.

4.5 Connect the compressed air supply to the inlet. Port A, Fig 1.

4.6 Turn on, and regulate the compressed air supply* such that the flowrate is 3 l/hr and pressure at the inlet is no more than 150 mb. This will purge the gas space above the test fluid. The purge flow should be of sixty minutes duration.

4.7 With the compressed air supply still flowing, replace and tighten plug B. The gas space in the Test Vessel will now become pressurised.

4.8 Regulate the compressed air supply pressure to 20 bar.

4.9 Repeat the above instructions on a further two vessels.

4.10 Heat the three vessels to the required temperature. Re-weigh vessels**

4.11 One test vessel should be removed after a period of 330 hours. Re-weigh vessel**

4.12 One test vessel should be removed after a period of 670 hours. Re-weigh vessel**

4.13 One test vessel should be removed after a period of 2,000 hours. Re-weigh vessel**

* Compressed air supply.
Certified content: CO_2 VPM<350
H_2O VPM<5
THC VPM<3

** Any weight change, compared to that at **Part 4.3** to be recorded.

5. FLUID ANALYSIS PROCEDURE

5.1 Colour Change Inspection

5.1.1 Carefully pour the contents of the Test Vessel, without disturbing any sediment or deposits, into a clean glass measuring cylinder, capacity 500 ml. Rinsing out any sludge or deposits is not necessary at this stage, since this aspect is covered in **Part 5.3**.

5.1.2 Using visual inspection, record the change in appearance/clarity with respect to unused fluid.

5.1.3 After the visual inspection, samples of this fluid should be set aside for the other tests. Samples should consist of the following volumes:

Acidity test	15 ml

The remaining test fluid is to be used for the viscosity test and corrosion test.

5.2 Viscosity Test

5.2.1 Test fluid in accordance with IP 71. All viscosity figures should be +\- 10%. Apparatus in contact with the fluid should be cleaned in accordance with **Part 2.1**. If filtering of the fluid is required, the solids must be retained for use in **Part 5.3**.

5.2.2 After viscosity testing, 300 ml of the fluid is to be set aside for use in **Part 5.5.1.** Any remaining fluid is to be retained for use in **Part 5.3**.

5.3 Sludge/deposits Examination

5.3.1 The Test Vessel may contain a sediment or other solid deposits. This is to be collected in apparatus suitable for membrane-filtering solid particles from the fluid. Deposits are to be removed from the Test Vessel by flushing with a suitable solvent. Careful use of a spatula may be used to aid the removal of stubborn debris.

5.3.2 Any solids removed by filtering in **Part 5.2.1** are also to be collected. This too can be done by flushing with a suitable solvent.

5.3.3 Any remaining fluid from **Part 5.2.2** is also to be collected in the membrane-filtering apparatus.

5.3.4 Dilution of the above solid/liquid mixture may be required before filtering. This is allowable, using a suitable clean solvent.

5.3.5 The filter element will be a PTFE membrane type having a 0.8 micro metre nominal pore size .

5.3.6 After filtering the fluid mixture, more solvent should used to remove any remaining test fluid from the membrane. The membrane will then be left to dry.

5.3.7 The mass of the debris (+/- 0.1%) can then be determined. A record should also be made of the size range and characteristic of the debris.

Record the debris against the following grades:

A	< 10 mgs/litre	**B**	10 - 100 mgs/litre
C	100 - 1000 mgs/litre	**D**	> 1g/litre

5.4 Acidity

5.4.1 A 15 ml sample will have been set aside in **Part 5.1.3** for this test.

5.4.2 If the test fluid is non-aqueous, record the acidity according to IP 1A.

5.4.3 If the test fluid is aqueous, record the acidity using a pH meter

5.5 Corrosion Test

5.5.1 A fluid sample (300 ml) will have been set aside in **Part 5.2.2** for this test.

5.5.2 Test the fluid sample in accordance with IP 135(b).

5.5.3 This test requires the test fluid to be mixed with 10% synthetic sea-water.

5.6 Reporting

5.6.1 An example of a report format is given at Figure 4.

6. HP/HT FLUID SCREENING PROCEDURE

6.1 Introduction

6.1.1 This procedure is to be carried out on control fluids intended for HP/HT applications, once they have completed **Parts 4 and 5** to the satisfaction of supplier and purchaser.

6.2 HP/HT TEST PROCEDURE

6.2.1 A suitable test arrangement is given at Figure 2, and an example system at Figure 3.

6.2.2 Prior to testing the test vessel will be cleaned according to the procedures detailed in **Parts 2 and 3**.

6.2.3 Fill the stainless steel Test Vessel completely with filtered test fluid.

6.2.4 Replace top assembly fittings etc, fully tighten and make connection to the hydraulic fluid pump.

6.2.5 Loosen top vent bleed plug by two turns.

6.2.6 Open fully the line isolation valve, turn on, and regulate the compressed air supply, see note below. The compressed air supply will be regulated to give a flowrate of 3 ltr/hour for a period of 60 minutes.

6.2.7 With the compressed air still flowing, fully re-tighten the top vent bleed plug and shut-off the isolation valve in the compressed air supply* line into the bottom of the Test Vessel.

6.2.8 Apply and stabilise the desired test pressure to the filled Test Vessel.

6.2.9 Heat the Test Vessel to the required temperature. Ensure that as the temperature of the test fluid increases the set pressure of the test fluid is monitored and is adequately regulated and maintained.

6.2.10 Maintain the set pressure and temperature for a period of 600 hours.

6.2.11 On completion of the 600 hour test period, prior to taking any samples, the test fluid should be allowed to cool to ambient temperature, followed by the pressure being reduced to atmospheric.

6.2.12 The fluid sample should be checked and analysed in accordance with **Part 5**.

7. FLUID ACCEPTANCE

7.1 Acceptance criteria to be agreed between the supplier and purchaser.

NOTE: Compressed air supply
Certified content: CO_2. VPM<350
H_20. VPM<5
THC. VPM<3

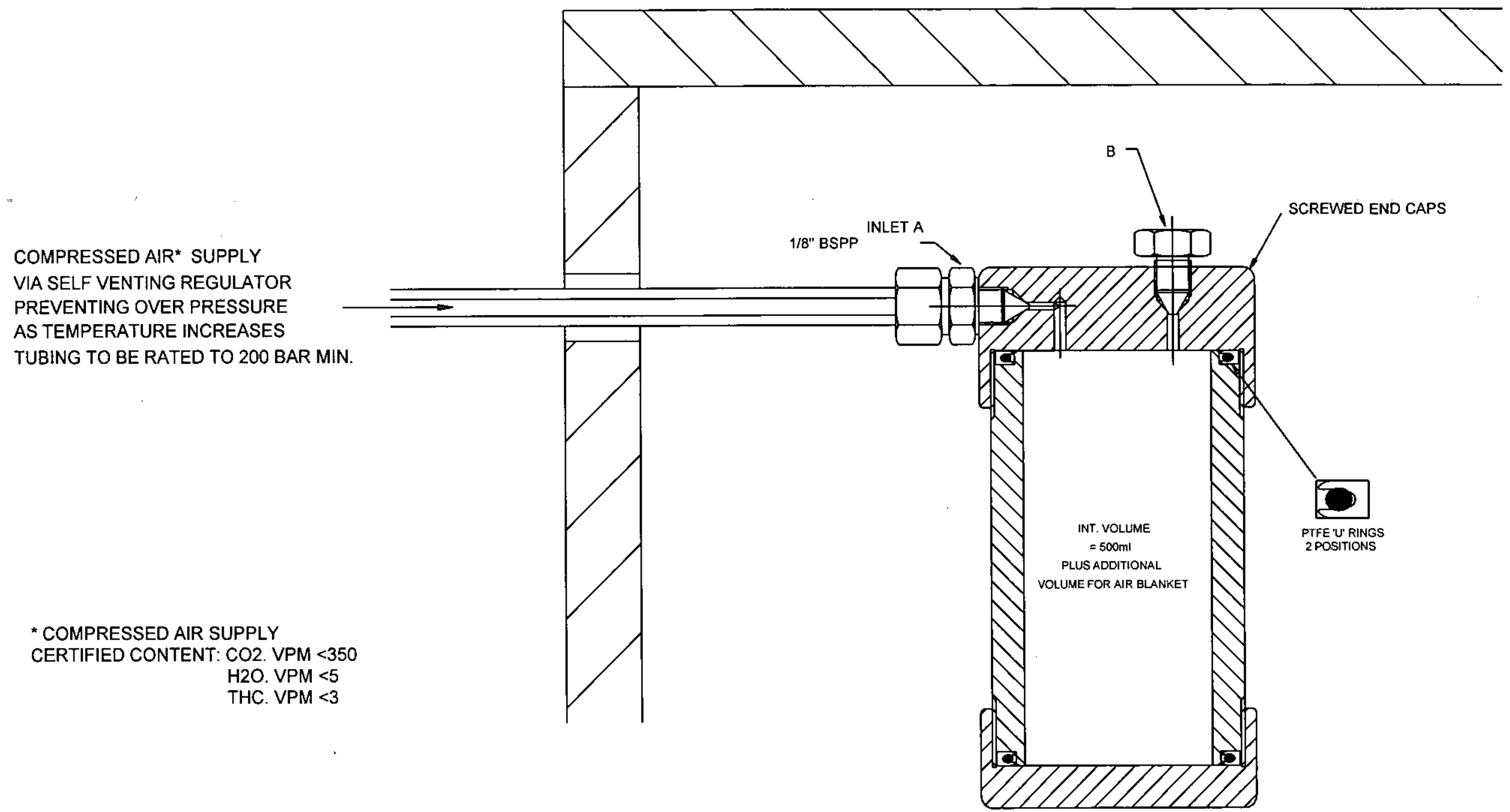

FIG.1 - LP SCREENING TEST VESSEL ARRANGEMENT

Contents

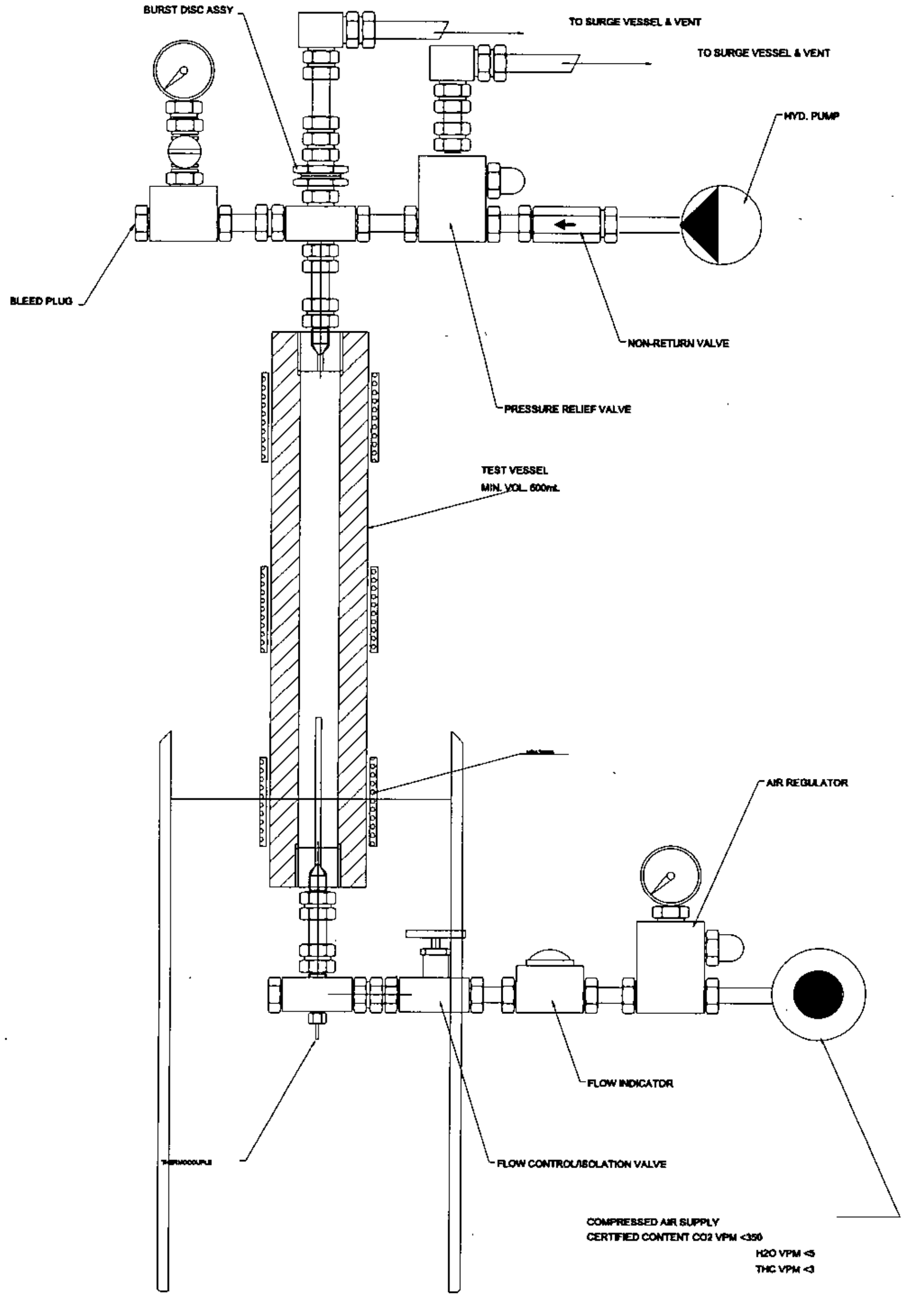

FIG.2 - EXAMPLE HP SCREENING TEST VESSEL ARRANGEMENT

- SECTION E -

Contents

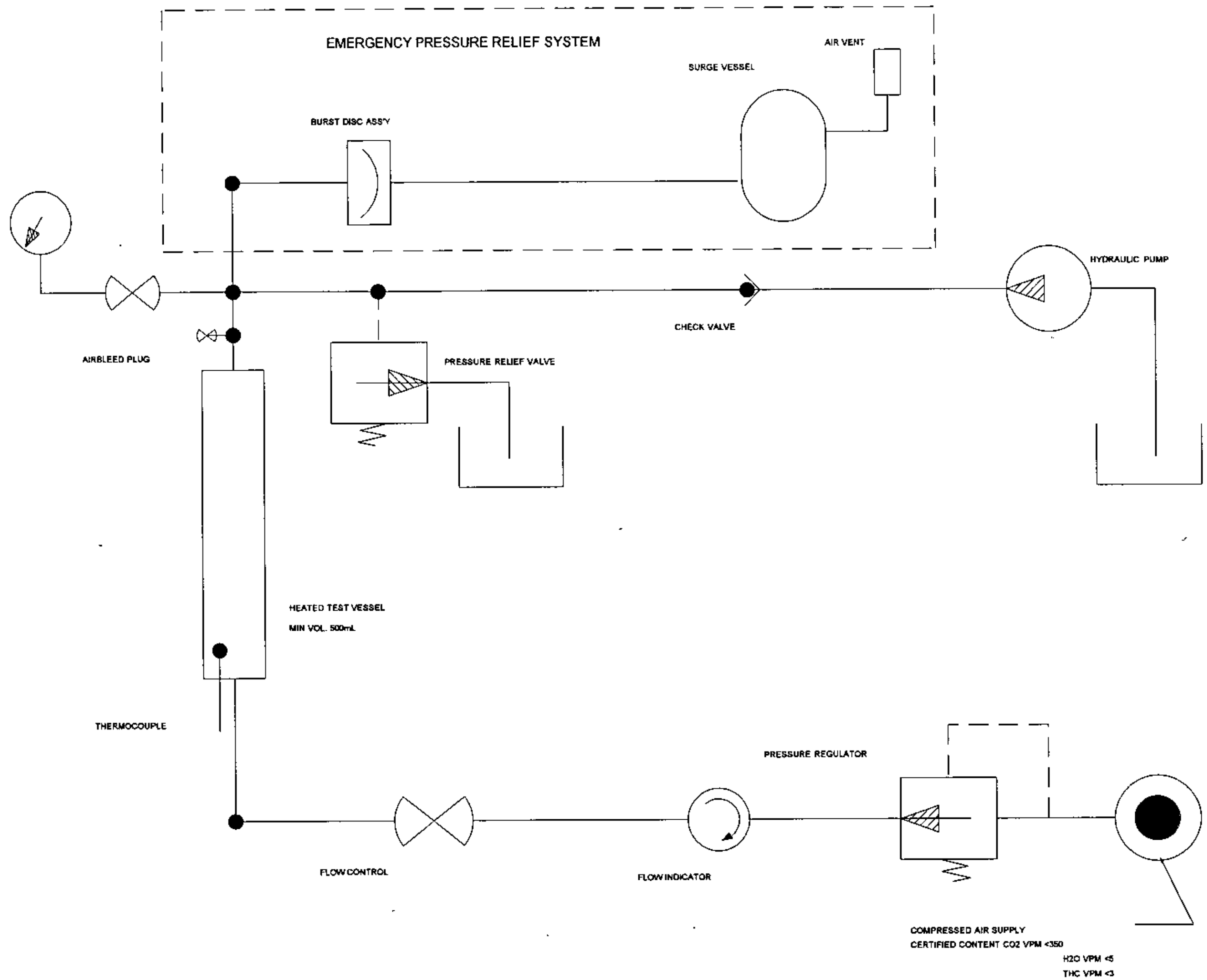

FIG.3 - EXAMPLE HP SCREENING TEST CIRCUIT SCHEMATIC

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APPENDIX 4

TEST VESSEL CLEANING PROCEDURE

Contents

1. Clean the interior of the Test Vessel, both end sections together with all pipes and fittings, with a suitable cleaning agent as agreed between the test house and the fluid supplier.

2. Thoroughly rinse the above components with mains hot water. This will remove detergents remaining from **1**.

3. Thoroughly rinse the above components with filtered de-ionised water. This will remove water impurities remaining from **2**.

4. Thoroughly rinse the above components with filtered iso-propyl alcohol. This will remove any remaining water from **3**.

5. Thoroughly rinse the above components with filtered Petroleum Spirit. This will remove any iso-propyl alcohol remaining from **4**.

6. The Test Vessel, end sections, pipes and fittings should be left to dry on a clean, no-fibre releasing surface. An air-line **should not** be used to aid drying, since this may contaminate the components.

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APPENDIX 5

VALVE HYDRAULIC ACTUATOR SCREENING

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HYDRAULIC ACTUATOR SCREENING

Prior to the System Validation Testing the customer should ensure that satisfactory screening of the hydraulic components to be tested have been carried out. These would be expected to include:-

- Materials compatibility testing for swell, shrinkage, change of mechanical properties or corrosion.
- Static pressure testing to 1.5 x system pressure.
- Dynamic testing to 1,500 operating cycles at rated pressure and temperature, with a satisfactory friction and leakage performance.

The actual values will depend on the detail design of the actuator and materials of construction.

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