	**AZERBAIJAN BUSINESS UNIT (AzBU)**	

Procedure for:
Leak Testing

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TABLE OF CONTENTS

1 INTRODUCTION

1.1 PURPOSE

The purpose of this document is to provide:

- Guidelines for assessing the risks and establishing the precautions to be taken when carrying out leak testing.
- Information that may be used as the basis for producing formal instructions for specific pressure and leak testing activities.

Prior to re-instatement of plant or equipment, any leak testing operations shall be conducted in accordance with this procedure.

A leak test (hydraulic where practicable) is performed to prove the pressure tightness (i.e. fitness for service) of joints, seals and glands etc. Whenever the integrity of containment systems is broken, either at hook-up/commissioning or post-operations phase. The prevention of even minor leaks is vitally important where flammable or toxic fluids are concerned.

Leak testing is performed at the Maximum Operating Pressure (MOP)

Leak pressure test may vary according to the test medium being used but shall never exceed 100% of the MOP. Gross (preliminary) air leak tests, using instrument air up to a maximum of 8barg, are often used at an early stage of hook-up/commissioning as a means of identifying large leaks, prior to performing the standard pressure tests.

1.2 DEVIATIONS

The procedures are written in sufficient detail that they should be able to be applied consistently at all sites. There may still be the requirement for some local rules covering site-specific logistical/administrative arrangements and local variations in responsibilities to reflect differences in organisational arrangements. These local rules should not deviate from the core processes within this document. Any form of deviation from this procedure, including but not limited to local rules, shall be requested and authorised in accordance with the SSOW Deviations from Regulations and Procedures procedure (Doc. No. UNIF-HSE-PRO-101)

1.3 SCOPE

This applies to all leak testing operations carried out on BP owned and managed sites and installations in AZBU.

1.4 DOCUMENT REVIEW

This document will be reviewed on an annual basis when users from the sites will have an opportunity to propose changes to the existing processes and procedures. The document Technical Authority will be responsible for coordinating this review.

1.5 SSOW SPECIFIC CROSS REFERENCES

This SSOW procedure shall, where appropriate, be used in conjunction with this suite of BP AzBU SSOW Procedures referenced below.

Document Number	Title of Procedure
UNIF - HSE- PRO - 101	Deviations from Regulations and Procedures
UNIF - HSE- PRO - 102	Incident Investigation and Reporting
UNIF - HSE- PRO - 103	Permit To Work
UNIF - HSE- PRO - 104	Authorisation
UNIF - HSE- PRO - 105	Task Risk Assessment
UNIF - HSE- PRO - 106	Energy Isolations-Electrical
UNIF - HSE- PRO - 107	Energy Isolations-Process
UNIF - HSE- PRO - 108	Confined Space Entry
UNIF - HSE- PRO - 241	Leak Testing

1.6 LANGUAGE FACILITATION

Due to the various languages spoken at site, there is a necessity to assist all with “an ease of understanding”. Therefore, the development and use of information tools are available.

2 ROLES AND RESPONSIBILITIES

2.1 OFFSHORE INSTALLATION MANAGER / SITE MANAGER / SITE CONTROLLER

The Offshore Installation Manager/ Site Manager/ Site Controller is responsible for ensuring that:

- All leak testing activities on their site are carried out in accordance with this procedure
- Formal records of all leak tests are maintained in accordance with this procedure

2.2 AREA AUTHORITY

The Area Authority shall:

- Fulfil the responsibilities of Area Authority as described in UNIF-HSE-PRO-103
- Ensure that leak testing operations comply with the guidelines within this document and/or ensure that any deviations from those guidelines are documented and authorised.

2.3 PERFORMING AUTHORITY

The Performing Authority shall:

- Have such practical experience and theoretical knowledge of the equipment to be tested so that he will be able to detect defects or weaknesses highlighted by the test and assess their importance to the integrity and function of the equipment. The Performing Authority must be qualified and trained to a standard sufficient to meet any applicable regulations.
- Fulfil the responsibilities of Performing Authority as described in UNIF-HSE-PRO-103
- Ensure that leak testing operations comply with the guidelines within this document and/or ensure that any inability to comply with the conditions of the Permit result in a re-assessment of the task.

3 COMPETENCY, TRAINING AND AWARENESS

3.1 COMPETENCY

BP's employees and those of its Contractors must provide adequate training for all personnel likely to be involved in Leak Testing to ensure that they possess the correct levels of competency.

All individuals shall be able to and be prepared to demonstrate their levels of competency to the Performing Authority, Supervisor and / or Leak Test Supervisor

This shall be demonstrated through individuals understanding, knowledge and the skills necessary to safely perform their assigned duties together with certifiable evidence of their competency.

3.2 UNDERSTANDING

All individuals shall be fully conversant with the:

- Scope of work and the potential hazards associated within their scope of work to ensure that they understand the hazards of the task in hand and all associated controls
- Safe systems of work (SSOW) elements associated with their scope of work, including but not limited to: PTW, Energy Isolations., purging and / or ventilation procedures,
- Relevant scope of work task risk assessments
- Should be trained to at least AGT2.

3.3 AWARENESS

All individuals shall be fully aware of:

- What they need to do in the event of an emergency on site
- What they need to do in the event of an incident related to their scope of work
- How to use the relevant communications equipment
- Self rescue
- How to use continuous gas monitoring equipment
- All aspects of the proposed Leak Test activities with focus on their particular duties

3.4 NEW INDIVIDUALS

New individuals shall not be assigned to the above tasks, unless under training and accompanied by a competent person (maximum 2 new starts to 1 supervisor) who is familiar with the hazards of Leak testing.

4 SELECTION OF TEST TYPE

4.1 GENERAL

A liquid medium (hydraulic) is the preferred means of testing and should be used for leak testing wherever possible, in order to minimise the stored energy.

The preferred liquid medium is water. However, the effect of the water, and any additives, on the metallurgy of the pressure envelope, and the effect of any residual water/additives on the process (eg formation of hydrates), shall be considered (eg when testing austenitic stainless steels, the water should be distilled or demineralised and contain <30ppm of chloride ions).

Selection of liquids other than water should take account of:

- The possibility of explosion resulting from the 'diesel' effect
- The boiling point relative to the test temperature

The flammability of the liquid, the flash point of which should not be less than 65°C, and at least 10°C above the maximum test temperature.

For Safety Considerations in Nitrogen Leak Testing see section 5.10.

4.2 HYDRAULIC

- Weight must be considered, particularly in context of equipment support e.g. pipe hangers, foundations
- Care must be taken with draining the test fluid on completion – in some cases the equipment may require flushing and/or drying.
- Some test fluids, typically water, may be incompatible with equipment materials
- Generally considered to be a "safe" test medium due to low levels of stored energy
- Internal leakage, e.g. through valves at the boundary, may require continuous pressuring of the equipment. In severe cases this can prevent a successful test
- Detection of leakage is typically by observation of fluids leaking to atmosphere at joints/connections under test. In cases where joints/connections are not visible then pressure drop off can be used as an indicator.

4.3 NITROGEN

- Relatively high levels of stored energy
- Large volumes may require supply of bulk nitrogen
- Considerable time may be needed to pressurize and/or vent
- Vent location(s) must be carefully selected so as to avoid any risk of asphyxiation to personnel
- Detection of leakage is typically by means of bubble test at joints/connections.

4.4 LIQUID FILL AND NITROGEN SQUEEZE

- Combination of both sets of attributes mentioned in sub sections 4.2 and 4.3.

4.5 NITROGEN – HELIUM

- Addition of a small proportion of helium (known as a tracer) enhances the searching qualities of nitrogen
- Typically supplied in bulk by a specialist contractor. Usually used for large-volume tests e.g. post shutdown
- Detection - Requires specialist detection equipment - can give a quantitative output

4.6 SERVICE

- Uses the service fluid under service conditions
- Typically restricted to non-hazardous and low pressure fluids
- Assurance must be available that the test does not introduce an unacceptable hazard into unproven system
- Test at normal operating pressure NOT the MAWP + 10%
- Detection will depend on the nature of the service fluid

5 LEAK TESTING GUIDELINES

5.1 COMMUNICATION

- Effective communication must be established between sites whenever the test envelope extends beyond one site, for example, pipelines.

5.2 TEST AREA ACCESS

Access to the test area shall be limited to essential personnel only. In particular, before the test commences compliance is required with the following points:

- The area shall be cordoned off (using tape, shields or barriers, etc) at an adequate distance from the equipment to be tested,
- Warning signs shall be posted at access ways, at other strategic positions, and on the equipment to be tested (including the doors of test workshops or other designated areas.
- Wherever possible, warnings of an imminent pressure test shall be broadcast.
- When testing, the test area boundaries shall be patrolled to ensure that no unauthorised personnel enter the area.

5.3 TEST EQUIPMENT

- Pressuring equipment shall be provided with suitably calibrated pressure control / regulator devices.
- Suitably calibrated pressure indicating device(s) shall be provided in a location clearly visible to the person controlling the pressure. Account should be taken of pressure variation caused by elevation changes inside the envelope.
- Pressuring equipment and plant/equipment shall not be left unattended at any time during the test.
- Pressuring equipment shall be isolated from the equipment under test and where practicable disconnected, when the test pressure has been reached. The pressurising valve should be locked in the closed position.
- All hoses are fully secured with tie-down devices capable of withstanding the forces used in the test

5.4 TEST BOUNDARY

- A Competent Person shall inspect the equipment to be tested, prior to testing, to ensure the equipment is free from any obvious flaws
- Within the test boundary, there should be an accessible and operable means of quickly and safely de-pressuring the test in the event of equipment failure etc.
- Prior to any hydraulic pressure test taking place it must be established that the foundation and supports of the equipment under test are rated and capable of

withstanding the combined weight of the equipment and the liquid required to fill it.

- The volume of equipment under test must be kept as small as possible so to minimise the stored energy within the pressurised system.
- Hazard and risk identification shall, as a minimum, consider:
    - the stability of components such as expansion joints and spring hangers
    - any interfaces with lower pressure systems or equipment (including heat exchangers, gauges, instruments etc) and must ensure measures are in place to ensure that such systems cannot be over-pressurised
    - any connected high pressure equipment such as pulsation dampers and accumulators.

5.5 ISOLATIONS

- Blanking devices such as spades, blinds and screwed plugs, etc. shall conform to the equipment specification. For plugs up to 1-1/2" NB, at least 7 to 8 threads must be engaged.
- Where testing is carried out against closed valves it must be assumed that the valves leak, and downstream equipment must be protected against subsequent over pressuring. This should be done by opening of suitable vents or by monitoring of downstream pressures

5.6 VENTS AND SAFETY VALVES

- Where the source pressure of the pressurising medium is greater than the test pressure, a safety valve should be fitted to the equipment/system being tested, set to relieve at a pressure that will prevent over pressurisation.
- Sufficient venting / draining points shall be provided in order to prevent trapping of pressurising medium behind non-return valves, check valves, between isolation valves, or within dead legs of the pressure envelope.
- When filling equipment/plant, adequate venting must take place at all high points or dead ends to release entrapped gas.

5.7 APPLYING THE TEST

- Pressure must be increased gradually to the final pressure, and sufficient time should be allowed for equipment and test medium to reach equilibrium. The pressure should be maintained sufficiently long for an inspection engineer to examine the entire system, and for any defects to have time to manifest themselves.
- Equipment must not be subjected to any form of shock loading during testing.
- When any equipment/plant is left under pressure for decay or leak observation, consideration must be given to the ambient temperature changes, particularly in respect to thermal expansion of liquids in a closed system.

5.8 MONITORING AND INSPECTION

- Pressure monitoring shall extend to any adjacent systems that are not positively isolated.
- Close examination of equipment at above maximum allowable working pressure shall not take place until the pressure has been held for 30 minutes. In any event, extreme care should be exercised until the pressure has been reduced to maximum allowable working pressure.
- If an inspection is required within the hold period, then pressure should be reduced to 80% of the test figure.

5.9 DEPRESSURISING AND RETURN TO SERVICE

- Extreme care shall be taken to ensure that all pressure has been relieved before opening any system that has been subject to pressure or leak test.
- On completion of the test, the pressure shall be reduced gradually and under controlled conditions until approximately atmospheric pressure is reached. More rapid draining of the test fluid can then take place.
- When draining equipment, adequate vents at the highest point must be opened to prevent drawing a vacuum. The drainage system must be capable of handling the flow from the pressurized equipment/plant without itself over pressuring.
- Consideration must be given to the possibility of test fluids being trapped behind non-return valves; it may often be necessary to vent or drain the test fluid from more than one point.
- Special consideration should be given to test fluid which may be contaminated with oil or contain corrosion inhibitor or other chemical. The method of disposal of test fluid must be included in Work Permit.
- Clamps or bolts on flanges shall not be loosened while the system is still under pressure. Clamps shall only be removed by competent personnel who have been trained in such procedures.
- Depending upon the test medium used, the return of equipment/plant back into service may produce additional hazards. In particular:
    - Residual water after draining may contaminate the product, or cause problems if the equipment is on high or low temperature service.
    - Systems containing air need to be inert prior to the introduction of process gas.
    - Inert gas must be vented to an area where personnel cannot be affected by it.
- Consideration must be given to the flushing and preserving of systems that are not being taken back into re-use immediately.

5.10 SAFETY CONSIDERATIONS IN NITROGEN LEAK TESTING

Nitrogen can asphyxiate, therefore great care should be taken to avoid gross leakage of nitrogen or nitrogen/helium. Particular care should be taken when opening up vessels that have been nitrogen purged or when the venting of nitrogen is taking place.

Pressure shall be introduced gradually into the system allowing adequate time for temperature equalisation; in this respect special attention is drawn to the cooling Joule-Thompson effect which occurs when letting down high-pressure nitrogen into the system to be tested. Nitrogen leak testing is performed with gases at high pressure. Therefore attention is drawn to the hazards of a possible release, with explosive force, of energy stored in the system. Systems under test shall be depressurised prior to bolt re-tightening, tensioning or other remedial action to improve leaks, the only exceptions to this being valve glands, which may be adjusted but not re-packed whilst the system is still pressurised.

The possibility of brittle fracture shall be considered when conducting a nitrogen leak test at metal temperatures near the ductile/brittle transition temperature of the steel. It is recommended that nitrogen leak testing should not be carried out when the ambient temperature is below 2°C on equipment and piping constructed from non-impact tested carbon steel materials with nominal thickness of >3/4in (19mm), (ie API 5L, A 106, A 105, A 216, etc). For non-impact tested carbon steel materials with nominal thickness >3/4in, a Competent Person shall specify the minimum metal temperatures for leak testing, based on requirements of either RP 42-1 or BS 5500. Sites are advised to identify any systems containing non-impact tested carbon steel and prepare the appropriate local test procedures.

Introducing nitrogen to a system introduces a large energy source, far greater than the energy stored in an equivalent liquid leak test. To minimise this stored energy, vessels which normally operate with a liquid level should be water filled (ensure water filling of the vessel is acceptable with respect to corrosion and scaling) prior to pressurising with nitrogen.

When a specialist contractor is contracted to carry out nitrogen leak testing rather than leak testing with nitrogen quads or low volume pumps the following additional measures apply:

- There will be a Pump Operator who will be in radio contact with the Leak Test Supervisor who will monitor system pressure. The pumping unit will be manually shut down on the instruction of the Leak Test Supervisor. The leak test crew should have a written procedure for radio protocol
- There will be an automatic pump trip (Overpressure Protection Device (OPPD)) that will shut down the pumping unit. The OPPD will be located close to the injection point so that it can monitor the highest pressure that will be seen in the Installation system
- Full flow pressure relief will be available via Pressure Safety Valves (PSVs). It is acceptable and appropriate for the PSVs on the Installation system/plant to be used for this purpose. However, if full flow pressure relief is not available via a plant system, then consideration should be given to the use of temporary PSVs supplied by the leak test contractor. If full flow pressure relief is not provided, then a Level 2 Risk Assessment should be completed and assurance gained that there is sufficient control in place to manage the HP/LP interface
- If it has been identified that the leak test contractor will have to supply PSVs, consideration should be given to the location that these PSVs would vent to in an emergency. The vent location should be surveyed and approved by the Installation

Area Authority with guidance from the leak test contractor on expected nitrogen plume.

6 RECORDS (CERTIFICATION)

All pressure / leak test results shall be formally certificated and recorded where necessary and all certificates included with the relevant equipment records.

7 REGISTERS

A register will be held on site of all personnel deemed competent for all the roles associated with Leak testing, and will be managed by the Site Manager / Site Controller / Offshore Installation Manager.

8 CONTRACTORS

In cases where leak testing is contracted to a specialist third party, the contract shall, as a minimum, specify the need to observe the requirements of this procedure and in addition the:

- Roles and responsibilities of the relevant BP and contractor personnel
- Authority for approval of procedures
- Required competency of the contractor personnel and the means of controlling compliance
- Keeping of test records
- Means of monitoring the contractor's safety management system.

9 AUDIT AND REVIEW

Business Units shall periodically review pressure and leak testing activities to verify general compliance with this procedure and with any local procedures. Such reviews shall include checks to verify compliance with any statutory requirements for periodic strength tests of equipment to demonstrate its continued fitness for service.

Independent audit of pressure / leak testing procedures and records shall be undertaken periodically at the request of the Site Manager.

APPENDIX A – LIST OF DEFINITIONS

Blank / Blanking:	Installation of a piping specification rated device such as a blind flange, spade or spectacle blind for the purpose of achieving positive isolation.
Boundary isolations:	Isolations that define the boundaries of a discrete pressure envelope.
Competent Person:	a person having such practical experience and theoretical knowledge of the equipment to be pressure tested so that he will be able to detect defects or weaknesses highlighted by the pressure test and assess their importance to the strength and function of the equipment. Competent Persons must be qualified and trained to a standard sufficient to meet any applicable regulations.
Leak test:	Application of pressure to a system in which the integrity of individual components has already been proven by a pressure test so as to identify leakage and leakage rates from component connections, valves etc.
Local procedures:	Site specific or Business Unit specific procedures that address the arrangements in place for the implementation of recommended and statutory practices.
Maximum Operating Pressure (MOP)	The maximum pressure expected during normal systems operation.
Pressure test:	A test involving the application of pressure to a system so as to apply a load greater than the maximum load generated in service but less than would cause physical damage. The test provides evidence that the system can safely withstand the service pressure. The term “Strength Test” may correctly be used instead.
Service leak test:	A leak test undertaken when a system is brought into normal service, where failure would not itself result in any undue hazard, e.g. sea water systems.

APPENDIX B – PRESSURE TESTING CHECKLIST

Note: This checklist in this appendix is provided as an *aide memoir* only, and is not intended for use as an approved test certificate or an official document:

Pressure Testing Checklist									
1.TYPE OF TEST:	STANDARD PRESSURE TEST:		LEAK PRESSURE TEST:						
2.TESTING MEDIUM:	HYDRAULIC:		PNEUMATIC:						
3.EQUIPMENT TO BE TESTED:									
Maximum Allowable Working Pressure (strength test) Maximum Operating Pressure (leak test)	Proposed Test Pressure:								
Incremental steps (%):	Duration each step:								
Duration of Test Pressure:	Written procedure provided:		YES		NO				
All threaded connectors, plugs, and caps secure and tight:			YES		NO				
All attachments unable to withstand Test pressure removed or isolated:			YES		NO				
Quality:	Temperature:								
4. TEST ENVELOPE INSPECTION:	Visual	YES		NO		MPI:	YES		NO
Radiography:	YES		NO		Other (specify):		YES		NO
5. EQUIPMENT ISOLATED AT:	and at:								
6. PRE-TEST PREPARATIONS:									
Equipment vented for filling at:	and at:								
Check facilities for venting trapped pressure from NRVs or between isolation valves			YES		NO				
Vents now SHUT			YES		NO				
Safety valves set to prevent test pressure being exceeded			YES		NO				
Calibrated test pressure gauge(s) fitted and visible to operator			YES		NO				
Any pipe support / expansion joints fitted with temporary restraints			YES		NO				
Pressuring equipment fitted with regulator and relief valve and is in sound condition			YES		NO				
Methods for upstream and downstream monitoring are in place			YES		NO				
Warning signs posted, barriers erected, and sentries in place			YES		NO				
PA announcement of proposed test has been organised / made			YES		NO				
7. ON COMPLETION OF TEST:									
Vents are open for slow depressurisation at:									
and at:									
Drains are open for draining of test medium at:									
and at:									
8. EQUIPMENT HAS BEEN RETURNED TO PRE-TEST EXCEPT FOR:									
and:			YES		NO				
9. CHECKLIST COMPLETED BY: Name: ..... Signature: ..... Title: ..... Date: ..... COMPETENT PERSON									

An overview of the leak testing process is shown within the main Energy Isolations-Process flowchart in Appendix C. A checklist to be used when planning leak tests is provided in Figure 1 below as a guide.

TEST PLAN / PROGRAMME

- □ Maximum Allowable Working Pressure (MAWP) or Maximum Operating Pressure (MOP) defined
- □ Test pressure defined
- □ Marked up P&ID's produced showing test boundaries
- □ Written test procedure developed
- □ Test medium selected (hydraulic considered rather than pneumatic)
- □ If pneumatic test planned, consider reducing the volume by water filling vessels
- □ Emergency depressurisation route identified
- □ Pressurisation / depressurisation procedures take account of the position of non-return valves
- □ Pressurisation procedure specifies hold points (25%, 50%, 75% of the test pressure)

PRE-TEST PREPARATION AND EQUIPMENT CHECKS

- □ All threaded connections, plugs and caps are secure
- □ All attachments unable to withstand test pressure are removed/ isolated
- □ Facilities have been checked for means of venting trapped pressure
- □ Safety valve set to prevent test pressure being exceeded
- □ Calibrated test pressure gauge(s) fitted and visible to operator
- □ Any pipe supports/expansion joints fitted with restraints
- □ Pressure equipment is fitted with regulator and relief valve and is in sound condition
- □ Methods of upstream and downstream monitoring are in place
- □ Warning signs and barriers erected
- □ PA announcement of proposed test has been organised
- □ Contingencies for leakage have been made
- □ Overpressure protection device in place for specialist contractor nitrogen testing
- □ Pumping unit connected to Isolation ESD system

POST-TEST CHECKS

- □ Vents to be opened at high points during liquid depressurisation
- □ Pressure to be released gradually
- □ Inert gases vented to flare or alternatively to a safe area
- □ Confirm that there is no trapped pressure within test envelope

Figure 1 Leak Testing Checklist

APPENDIX C – GUIDANCE NOTES

LEAK TESTING ACCEPTANCE CRITERIA

This section defines the allowable leak rates for different test medium and equipment type and duty.

Acceptance Criteria for Hydraulic Testing

For hydraulic testing using water the test should be conducted for a minimum of 30 minutes. A test should be deemed successful if no significant reduction in pressure is observed over the test period and all joints and connections have been visually inspected for leakage. In some cases it may not be possible to maintain a constant test pressure due to trapped air in the system or passing valves. In this case the visual inspection is vital in confirming an acceptable test.

Acceptance Criteria for Nitrogen Testing

For nitrogen testing, depending on the scope of the test, there are two primary means of confirming an acceptable test. These are:

- Bubble testing
- Leak rate measurement using a helium tracer

Helium tracer testing is normally used for large scale testing of plant or the installation of new equipment involving a specialist contractor. Bubble testing is normally applicable when carrying out smaller scale testing using nitrogen quads.

Bubble Testing Criteria for Hydrocarbons

Bubble Testing Method	Acceptance Criteria
Method 1 involves the application of a soap solution to the joint and monitoring for surface bubbles.	No presence of continuous bubble growth detected in 60 seconds for flanges up to and including 4in NB and 90 seconds for flanges above 4in NB.
Method 2 involves taping the joint and inserting a 1/4in diameter tube from the flange into a water bucket and monitoring the number of bubbles released.	5 bubbles/min.

Note: 5 bubbles/min approximates to 15scf/year from a 1/4in tube.

Helium Tracer Testing

Leak rate measurement in the case of helium tracer testing involves taping of individual flanges and measurement of leakage using a measurement probe. The following leakage criteria apply:

Leakage Rates (scf/yr)			
Helium Tracer Testing Method	**Acceptance Criteria (scf/year)**		
	Target		**Maximum**
	Closed Module	**Open Module**	
Oil	100	200	400
Gas <50barg	50	100	200
Gas >50barg	20	40	100

Acceptance of leak rates in the range between target and maximum allowable leakage is by exception only and review by the appropriate Technical Authority. The review shall take into account fluid type, location of joint and ventilation and subsequent monitoring programme.