	TECHNICAL SPECIFICATION	Nº:	I-ET-3010.00-5520-861-P4X-003	
	CLIENT:		SHEET:	1 of 15
	JOB:			
PETROBRAS	AREA:			
	TITLE: VIRTUALIZATION OF AUTOMATION SYSTEM COMPUTERS		ESUP	
			INTERNAL	

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INTERNA

SUMMARY

1 INTRODUCTION

1.1 Objective

1.1.1 This Typical Technical Specification describes the minimum functional and technical requirements for the design and supply of the Virtualized Solution for the Automation and Control Architecture of the UNIT.

1.1.2 This document shall be read in conjunction with the documents listed in item 2.2.

1.2 Definitions

1.2.1 Refer to I-ET-3010.00-1200-940-P4X-002 – GENERAL TECHNICAL TERMS for the definition of words emphasized in upper case along this document.

1.3 Abbreviations, Acronyms, and Initialisms

1.3.1 The following abbreviations, acronyms and initialisms are used in this document:

CPU	Central Processing Unit
ECC	Error Correction Code
EMI	Electromagnetic Interference
FAT	Factory Acceptance Test
HDS	Virtual Historical Data Server
HMI	Human Machine Interface
HVAC	Heating, Ventilation and Air-conditioning
LACP	Link Aggregation Control Protocol
OVF	Open Virtual Format
RAID	Redundant Array of Inexpensive Disks
RAM	Random-Access Memory
RFI	Radio Frequency Interference
RTDS	Virtual Real Time Data Server
SAT	Site Acceptance Test
SIT	Site Integration Test
SOS	Supervision and Operation System
SSD	Solid-State Drive
USB	Universal Serial Bus
VCI	Volatile Corrosion Inhibitor
VM	Virtual Machine

2   REFERENCE DOCUMENTS, CODES AND STANDARDS

2.1   External references

2.1.1   International Codes, Recommended Practices and Standards

IEC – INTERNATIONAL ELECTROTECHNICAL COMMISSION

IEC   62381   AUTOMATION SYSTEMS IN THE PROCESS INDUSTRY-FACTORY ACCEPTANCE TEST (FAT), SITE ACCEPTANCE TEST (SAT) AND SITE INTEGRATION TEST (SIT)

2.1.2   Brazilian Codes and Standards

2.1.2.1 All *Secretaria de Inspeção do Trabalho* Regulatory Standards (NRs) shall be followed.

2.1.3   Classification Society

2.1.3.1 Project's Detail Design Phase documents will be submitted to Classification Society's approval and/or certification.

2.1.3.2 The design, installation and operation shall strictly follow the Classification Society's requirements, along with the specific requirements identified in this document, also including all referenced document requirements.

2.2   Internal References

2.2.1   Typical Documents

2.2.1.1 Typical Documents are those that contain functional and technical description of a system or equipment. They shall be used as the main specification for the Project.

2.2.1.2 Typical Document List

I-ET-3010.00-1200-940-P4X-002	GENERAL TECHNICAL TERMS
I-ET-3010.00-5140-700-P4X-003	ELECTRICAL REQUIREMENTS FOR PACKAGES FOR OFFSHORE UNITS
I-ET-3010.00-5520-888-P4X-001	AUTOMATION PANELS
I-ET-3010.00-5520-861-P4X-002	SUPERVISION AND OPERATION SYSTEM - SOS
I-ET-3010.00-5520-800-P4X-004	AUTOMATION NETWORK REQUIREMENTS.

2.2.2   Specific Project Documents

2.2.2.1 This section mentions documents that are referenced along the text and that are part of a specific Project. The documents title and number may vary slightly from one Project to another. Project's DOCUMENT LIST shall be consulted to verify the correct document number and title.

2.2.2.2 Specific Project Document List

TECHNICAL SPECIFICATIONS (ET)

INSTRUMENTATION ADDITIONAL TECHNICAL REQUIREMENTS

SPECIAL MONITORING SYSTEMS

DRAWINGS (DE)

AUTOMATION AND CONTROL ARCHITECTURE

NETWORK INTERCONNECTION DIAGRAM

CENTRAL CONTROL ROOM LAYOUT

DESCRIPTIVE MEMORANDUM (MD)

AUTOMATION AND CONTROL SYSTEM FUNCTIONS

LISTS (LI)

EQUIPMENT LIST

2.2.3 PETROBRAS Reference Documents

DR-ENGP-M-I-1.3 SAFETY ENGINEERING GUIDELINE

2.3 In cases where Brazilian regulatory standards (*Secretaria de Inspeção do Trabalho*) and INMETRO regulations are more restrictive, these shall superpose all codes and regulations listed in item 0, since they are enforced by Brazilian law. Additionally, in cases of conflicting requirements, Brazilian regulatory standards shall be adopted.

3 ENVIRONMENTAL AND OPERATIONAL CONDITIONS

3.1 For environmental and operating conditions and/or any requirements regarding this topic, refer to project's technical specification entitled "INSTRUMENTATION ADDITIONAL TECHNICAL REQUIREMENTS". For the specification of SOS computers, special attention shall be given to the dynamic loads imposed by the vessel motions during tow and on location and to the temperature of the indoor ambient on loss of HVAC.

3.2 Electrical, mechanical and sizing characteristics of virtualization solution panels are described in I-ET-3010.00-5520-888-P4X-001 – AUTOMATION PANELS.

3.3 Automation and Control Architecture will be used 7 days/week, 24 hours/day.

3.4 Ingress protection and protection against explosive atmosphere, if any, are defined in I-ET-3010.00-5520-888-P4X-001 – AUTOMATION PANELS.

3.5 For the exact physical location of computers, servers and panels, see project's documents entitled "AUTOMATION AND CONTROL ARCHITECTURE", "CENTRAL CONTROL ROOM LAYOUT" and "EQUIPMENT LIST".

4   GENERAL REQUIREMENTS

4.1   The Virtualization Solution presented in this document shall be applied to the "Operation and Supervision" layer of the Industrial Automation pyramid, which acts as the operator interface facility with the "Control and Safety" and "Field" layers (See Figure 1).
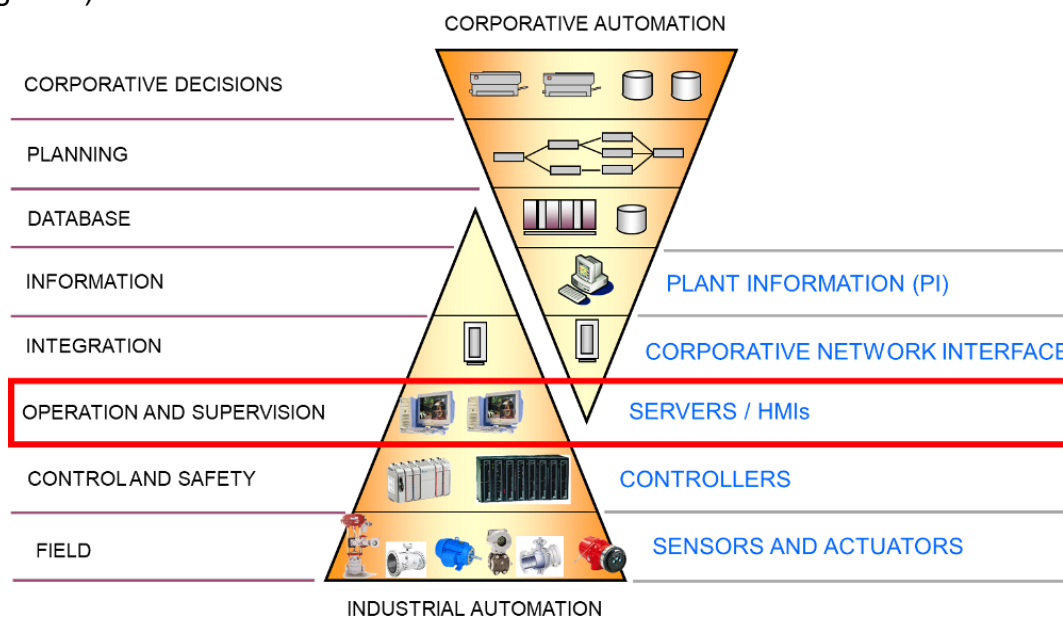

Figure 1 – Industrial and Corporative Automation Pyramids

4.2   The virtualization solution consists of, but is not limited to the following items:
- Physical hosts;
- Clusters;
- External Physical Storage Devices;
- Hypervisors;
- Virtual machines;
- Virtual solution software suite, including management software (host and storage), remote access software etc.;
- Storage and Cluster panels and accessories;
- Physical network equipment and accessories;
- Thin clients for HMI.

4.3   The Virtualization Solution shall be the basis of the Supervision and Operation System (SOS). For more information, see I-ET-3010.00-5520-861-P4X-002 - SUPERVISION AND OPERATION SYSTEM – SOS and project drawing entitled "AUTOMATION AND CONTROL ARCHITECTURE".

4.4   See project drawing entitled "NETWORK INTERCONNECTION DIAGRAM" to see the implementation of the SOS LANs and interconnection of the different components of the virtualized solution.

5 VIRTUALIZED SOLUTION MINIMUM REQUIREMENTS

5.1 General

5.1.1 The available power supplied by the UNIT to be used by all virtualized solution equipment is defined in I-ET-3010.00-5140-700-P4X-003 – ELECTRICAL REQUIREMENTS FOR PACKAGES FOR OFFSHORE UNITS.

5.1.2 Only mission-critical computers and equipment suitable for industrial environment shall be used. Refurbished, used or economy-line equipment are forbidden.

5.1.3 All CPU cabinets shall have internal shock absorbers to protect the internal components from balance movements and vibration.

5.1.4 Cable organization criteria and equipment (patch panels, organizers etc.) shall be according to I-ET-3010.00-5520-800-P4X-004 - AUTOMATION NETWORK REQUIREMENTS.

5.2 Physical Hosts

5.2.1 The term "host" or "physical host" refers to a physical server which has physical processor(s) and physical RAM memory. In this server, a hypervisor type 1 will be installed, and virtual machines will be executed.

5.2.2 All physical host machines shall be industrial 19-inch/1u rack-mounted servers for installation inside 19-inch panels.

5.2.3 Every host shall have dual power supplies, each one fed by a different UPS. The power supply is made available by the UNIT, as per item 5.1.1.

5.2.4 As a minimum requirement, a host shall have two CPUs with twenty (20) cores each with Hyper Threading (40 Threads), totalizing forty (40) cores (80 Threads) per host, and 256 GB of ECC RAM memory, expansible to 1TB and running at the maximum speed supported by the processors.

5.2.5 All automation hosts shall have the same characteristics, regardless of the cluster they belong to. This is especially valid for physical processors: all hosts shall have the same brand of physical processor. This makes it easier to manage the cluster with focus on hot swap of virtual machines among hosts.

5.2.6 All equipment (servers, switches, storage devices etc.) shall be capable of withstanding the maximum temperature, humidity and salinity requirements indicated in project's technical specification entitled INSTRUMENTATION ADDITIONAL TECHNICAL REQUIREMENTS.

5.2.7 For host sizing criteria, and for the complete virtual machines list, see project document AUTOMATION AND CONTROL SYSTEM FUNCTIONS.

5.2.8 Storage drives shall be implemented in such way that the change over between the main and the backup drive shall be done automatically.

5.3 Clusters

5.3.1 A cluster is a group of hosts working together. When a host joins a cluster, the host's resources become part of the cluster's resources. The cluster manages the resources of all hosts within it. In other words, the clusters are a group of servers that work together in order to guarantee system availability and can be viewed as a single system. The virtual machines (including virtual servers) shall be executed on a physical server, which is part of a cluster.

5.3.2 The SOS virtualized architecture shall be composed of the following four (04) clusters:

- HULL SOS PROCESS CLUSTER
- TOPSIDES SOS PROCESS CLUSTER
- HULL SOS SAFETY CLUSTER
- TOPSIDES SOS SAFETY CLUSTER

5.3.3 TOPSIDES SOS PROCESS CLUSTER and TOPSIDES SOS SAFETY CLUSTER shall both be contained in TOPSIDES SOS CLUSTERS PANEL. Similarly, HULL SOS PROCESS CLUSTER and HULL SOS SAFETY CLUSTER shall both be contained in HULL SOS CLUSTERS PANEL.

5.3.4 The virtualized solution shall provide complete diagnosis of the clusters as well as the state of the virtual machines. In addition to the virtualization system diagnostic tool, virtualization system status screens shall be developed in SOS.

5.3.5 The Virtualization system shall be fault tolerant, where in the failure of a host, the virtual machines shall be redistributed, automatically, to the other host in the cluster without degradation of system performance.

5.3.6 The clusters shall allow any physical hardware individually (as a network adapter, RAM memory, etc.) or even one host of the cluster to be exchanged without degradation in the performance of the system. The resources redistribution shall be transparent during the exchange.

5.3.7 Redundant virtual machines shall not run in the same physical host of a Cluster. For example, virtual machines of PROCESS RTDS A and PROCESS RTDS B shall run in different hosts.

5.3.8 Before specifying hardware and software for the virtualization solution each virtual machine related to all software and applications shall be evaluated in order to validate all allocated resources.

5.3.9 Each cluster shall be specified according to the scenario in which every virtual machine is working on maximum performance regarding processing, memory and network traffic. If there is one failure at any physical host, load shall be automatically balanced between the other physical hosts, not exceeding 70 (seventy) % of processing and memory available to the cluster.

5.3.10 A dedicated network shall be foreseen for virtual machine migration between physical hosts of a cluster without downtime. Each cluster shall have its own dedicated network and switches. This network is denominated "Management LAN". For redundancy issues, the management LAN switches from PROCESS

CLUSTER and SAFETY CLUSTER of the same panel shall be installed in a ring topology.

5.3.11 Cluster Hardware

5.3.11.1   TOPSIDES SOS CLUSTERS PANEL and HULL SOS CLUSTERS PANEL are panels consisting of multiple sections, as specified in the project's EQUIPMENT LIST. Each section is designed to accommodate a 19" rack (refer to item 3.2 for detailed dimensions of each section). The TOPSIDES SOS PROCESS CLUSTER and TOPSIDES SOS SAFETY CLUSTER shall be evenly distributed among the 19" racks within the TOPSIDES SOS CLUSTERS PANEL. Similarly, the HULL SOS PROCESS CLUSTER and HULL SOS SAFETY CLUSTER shall be evenly distributed among the 19" racks within the HULL SOS CLUSTERS PANEL.

5.3.11.2   Each cluster shall have the adequate number of physical hosts in order to guarantee performance requirements. No cluster shall have less than 3 (three) physical hosts.

5.3.11.3   The HULL SOS CLUSTERS PANEL and TOPSIDES SOS CLUSTERS PANEL will be located in the designated sections as defined by the EQUIPMENT LIST of the project. Upgrades to the internal components of the host may be necessary, in accordance with the minimum specifications outlined in the AUTOMATION AND CONTROL SYSTEM FUNCTIONS, to avoid the need for larger panels.

5.3.11.4   In case additional sections are required for a cluster panel beyond what is specified in the project's EQUIPMENT LIST, the new dimensions shall be submitted to PETROBRAS for approval.

5.3.11.5   Each cluster shall have one (10 Gbps Ethernet) switch for cluster management and for connection of the redundant external physical storage devices, this switch shall be in ring topology with the other management LAN switch of the same panel. See I-ET-3010.00-5520-800-P4X-004 - AUTOMATION NETWORK REQUIREMENTS for further requirements of network components.

5.3.11.6   All hardware (hosts, storages and their components) shall be of the most recent model, last release, at purchase time.

5.3.11.7   All equipment shall be capable of communication in the SNMPv2 protocol for network equipment supervision purposes.

5.3.12 Cluster Software

5.3.12.1   The virtual machine management software, i.e. the hypervisor, shall be type 1 (bare metal).

5.3.12.2   The hypervisor shall provide a software management, which will allow the management, complete diagnosis (alarms and failure), settings and state of cluster and their virtual machines. For that, diagnostic screens shall be developed in SOS. Virtualization provider and SOS provider shall communicate with each order in order to provide any drivers necessary for the intercommunication of the

systems.

5.3.12.3   In the case of failure of a host, the virtual machines shall be redistributed, automatically, to the other hosts in the cluster, according to load balancing, without system performance degradation.

5.3.12.4   The management software of the hypervisor and all other virtualization related software shall be of the most recent version of the product, at its latest release.

5.3.12.5   The management software of the virtualized solution shall support import and export virtual machines with OVF (Open Virtual Format) through graphics interface by that software.

5.3.12.6   The management software of virtualized solution shall meet, at least, the following requirements:

- Support to management and settings of virtual machines, physical hosts and cluster and Storage by policies.
- Have or provide conversion tools P2V (Physical to Virtual) about machines.
- Have any interface to view relationship between physical and virtual resources.
- Provide resource for updating virtual machines (online and offline).
- Automatic migration of virtual machine(s) to another physical host when occur an automatic or manual shutdown of prior physical host.
- High availability of infrastructure.
- Hot swap (hot migration) of virtual machines among hosts, remaining their states (online or offline) untouchable and uninterrupted for user.
- Online monitor of virtual and physical resources about virtual machines, physical hosts and cluster, any alarm shall show up if occurs.
- Easy integration with Virtual Security Appliances and also Directory Services such as (Lightweight Directory Access Protocol and Active Directory).
- Be able to addition and manage Storages.
- Provide API of integration between Hypervisor and Storage infrastructure.
- Be able to migrate online data among Storages also thin provisioning of disks when create virtual machines and Have support to LACP (Link Aggregation Control Protocol).
- Continuously monitor CPU RAM and Storage usage in order to adequately redistribute / allocate VMs optimally among hosts of the same cluster (load balance).
- In case of resource scarcity, the ability to choose which VMs shall remain operational. Software shall allow choosing VM priority configuration.

5.4 External Physical Storage

5.4.1 Each cluster shall contain a pair of external physical storage devices with hot plug SSD.

5.4.2 The storages shall have the following characteristics:

- TOPSIDES SOS PROCESS CLUSTER STORAGE A/B – RAID 6 each
- TOPSIDES SOS SAFETY CLUSTER STORAGE A/B – RAID 6 each

- HULL SOS PROCESS CLUSTER STORAGE A/B – RAID 6 each
- HULL SOS SAFETY CLUSTER STORAGE A/B – Part of the SSDs shall be in RAID 1 (the part that contain the historian virtual images) and part of the SSDs shall be in RAID 6 (the part containing the remaining virtual images).

5.4.3 HULL SOS SAFETY CLUSTER STORAGE A/B shall each contain a set of SSDs that shall be easily ejected during emergency shutdown level 4 (ESD-4). They shall be configured in order to contain the SOS historian virtual images and shall be properly identified, in order to ease locating the removable devices in case of emergency.

5.4.4 Historian machines shall run exclusively in Storage Servers, so that all history data is contained within the detached SSDs.

5.4.5 The removal of ejectable SSDs shall not corrupt data and shall be an easily revertible procedure.

5.4.6 Every storage server shall have dual power supplies, each one fed by a different UPS. The power supply is made available by the UNIT, as per item 5.1.1.

5.4.7 If hyper convergent storage solution is adopted, RAID 6 shall be used.

5.4.8 The storage sizing shall meet the performance requirement presented in item 6.

5.4.9 The waterproof case for the removable drives shall have at least the following characteristics:

- IP67, STANAG 4280, and Def Stan 81-41 certificates;
- Airtight gasket;
- Automatic pressure valve;
- Shock-resistant;
- Lightweight (to be easily transported by hand);
- Ergonomic, easy to grip handle;
- Internal antistatic foam.

5.5 Hypervisor

5.5.1 The hypervisor is a virtual machine monitoring software. It is responsible for creating and running virtual machines.

5.5.2 The hypervisor for the Automation Architecture Virtualized Solution shall be a type 1 hypervisor (bare metal). This means that the hypervisor shall not require an underlying Operating System (OS).

5.6 Virtual Machines

5.6.1 A virtual machine (VM) or a virtualization process is a software which executes other software as if it were an isolated physical computer. It requires an Operating System to be installed and executes applications by using resources from a pool provided by the virtualized solution's management software. A VM can be viewed as an independent computer/server.

5.6.2 A list of the currently foreseen virtual machines is present in project document AUTOMATION AND CONTROL SYSTEM FUNCTIONS. This list shall be updated during Detailed Engineering Design. This list shall be the basis for host internal components sizing, cluster sizing (i.e., number of hosts) and external physical storage sizing.

5.7 Thin clients

5.7.1 Thin Clients shall meet the following requirements: 2 x Gigabit Ethernet interface (RJ 45), 4 x HDMI (Full HD) or display port, multiple RDP support, 4 USB ports; 8 GB RAM Memory; 1 physical processor with 4 core at least and IP degree 4X, at least, according to IEC-60529.

6 PERFORMANCE REQUIREMENTS

6.1 Virtual machines performance

6.1.1 This section is dedicated to specifying the performance of each individual virtual machine.

6.1.2 OS performance is defined here to be the performance of the virtual machine with only the OS running. The main applications of a virtual machine are closed.

6.1.3 Idle performance is defined here to be the performance of the system when all main applications of a virtual machine are running without process of system machine upheaval (i.e., no antivirus scans active, no emergency occurring during SOS).

6.1.4 Peak performance is defined here to be the performance of the system when all main applications of a virtual machine are running, but there is something requiring more than usual from the machine processing (for example, antivirus scans, process upheaval). This is the worst-case scenario, and therefore performance requirements for this shall always be met.

6.1.5 Performance requirements for each and every virtual machine:

- At peak performance:
  o Processor usage shall never stay at 100% for more than 10 seconds.
  o RAM Usage shall never exceed 90%.
  o Virtual HD usage shall never exceed 90%.
- Idle performance:
  o Processor usage shall not surpass 70%.
  o Consumption of the allocated RAM shall not surpass 70%.
  o Virtual HD usage shall not exceed 70%.
- OS Performance:
  o Processor usage shall not surpass 10%.

6.2 Cluster performance

6.2.1 This section is dedicated to specifying the performance requirements for the clusters.

6.2.2 When all virtual machines are running, cluster performance shall stay below 60% of its total capacity, including the storage usage.

7 ACCEPTANCE TESTS

7.1 All deviations and anomalies found during Factory Acceptance Test (FAT), Site Acceptance Test (SAT) and Site Integration Test (SIT) shall be adequately registered according to punch list control system defined in contract.

7.2 The acceptance tests shall be according to IEC-62381 – AUTOMATION SYSTEMS IN THE PROCESS INDUSTRY – FACTORY ACCEPTANCE TEST (FAT), SITE ACCEPTANCE TEST (SAT) AND SITE INTEGRATION TEST (SIT).

7.3 Detailed FAT, SAT and SIT proceedings shall be submitted to PETROBRAS for approval according to the informed schedule, including the testing architecture for the FAT, if it is not the same as SAT

7.4 All networks shall be statically and dynamically tested.

7.5 Fault Test considering, at least, the behavior verifying of load balance of cluster when occur a fault in the physical host shall be performed both during FAT, SAT and SIT. It shall be checked whether running states of virtual machines halt while wait for load balance of cluster. Additionally, no functionality of SOS (such as performance, navigation etc.) shall be lost.

7.6 Factory Acceptance Tests (FAT)

7.6.1 The following tests shall be performed at Factory (FAT), besides the tests required at I-ET-3010.00-5520-888-P4X-001 - AUTOMATION PANELS, where applicable, prior to delivery:

- Mechanical inspection;
- Hardware inventory check;
- Software licensing check;
- Wiring and Termination inspection;
- Start-up Test;
- Visualization/operation;
- General System functions including hardware and software redundancy and diagnostic check;
- Black recovery test, i.e., shutdown of all hosts and boot them afterwards;
- Hot swap maintenance tests, i.e., replacement of hardware, as networks interfaces, RAM memory and even a host
- Functional test;
- Subsystems interface test;
- Screens and logic test.
- Data exchange and response time tests.
- Storage server removable HD ejection and data integrity tests after ejection.

7.6.2 FAT shall be witnessed, to be agreed between PETROBRAS and Panel SUPPLIER during Project. FAT report tests shall be signed and sent to PETROBRAS.

7.6.3 Prior to the witnessed FAT, SUPPLIER shall send the Tests proceedings to PETROBRAS, according to Project's schedule, and shall execute previous tests and present the documentation to PETROBRAS, in order to reduce repairs and/or modifications during FAT.

7.6.4 The FAT shall be fully documented, including any equipment failure, repairs, or replacements. The FAT procedure shall include handling over all records made during the construction period such as test results, list of changes, as-built drawings, calibration certificates and any other documentation.

7.6.5 All documentation (project and tests) shall be sent in digital media. All PDF files shall be searchable.

7.6.6 Testing methods and accuracy of measurements shall be subject to the Classification Society and PETROBRAS approval.

7.6.7 Any malfunction of the equipment shall be rectified and tested again, at SUPPLIER'S expenses, and be submitted to PETROBRAS for approval. Evidence of the correction shall be presented.

7.6.8 In FAT location, all facilities such as redundant external power supplies shall be available. Ambiance temperature shall be controlled. The FAT facility shall include adequate air conditioning to ensure that the testing environment (where there are numerous screens and other equipment generating large amounts of heat) is maintained at a comfortable temperature (less than 25 °C).

7.6.9 Electrical and RFI & EMI Immunity tests shall be according to project's "INSTRUMENTATION ADDITIONAL TECHNICAL REQUIREMENTS" technical specification.

7.6.10 Functional Tests shall be as described below:
- Complete system functional test, with simulation of all input situations and observation of expected outputs; the overall reaction time shall be verified;
- Devices shall be tested according to test and operation device manuals.

7.6.11 FAT report shall include a punch list with all non-impeditive deviations and anomalies that will be treated in field, including the date for treatment deadline.

7.6.12 During FAT, all Ex certificates of each component and of the assembly shall be verified and validated.

7.6.13 During FAT, inventory shall be kept of all components and spare parts to guarantee traceability and availability.

7.7 Site Acceptance Test (SAT)

7.7.1 All tests performed at the factory (FAT) shall be repeated at the installation site (SAT). IEC 62381 requirements shall also be taken into account.

7.7.2 During SAT, any necessary design modifications after FAT shall be tested and FAT punch list items shall be treated.

7.7.3 After the installation of virtualized solution components at the site, at least the following tests (SAT) shall be provided in order to assure that the equipment is correctly installed:

- Mechanical Inspection;
- Hardware and Software inventory check;
- Start-up/Diagnostic Check;
- Software downloads and functional tests;
- Storage server removable HD ejection and data integrity tests after ejection.

7.8 Site Integration Test (SIT)

7.8.1 For Site Integration Tests (SIT) refer to IEC-62381 – AUTOMATION SYSTEMS IN THE PROCESS INDUSTRY – FACTORY ACCEPTANCE TEST (FAT), SITE ACCEPTANCE TEST (SAT) AND SITE INTEGRATION TEST (SIT).

8 PACKING REQUIREMENTS

8.1 On completion of FAT, all equipment shall be prepared for shipment and storage.

8.2 Equipment supplied loose shall be packed and crated for transportation. In addition, if any rack equipment is susceptible to transportation damage, it shall be removed from the system rack for separate packing and crating.

8.3 To prevent corrosion, VCI shall be used adequately, where applicable, as part of preparation for shipment and storage instead of desiccants such as silica gel. The latter shall be used only in cases where VCI is not applicable. Both VCI and desiccants shall not be used together for protecting the same compartment.

9 DOCUMENTATION

9.1 The virtualized solution shall be supplied with complete documentation, to be issued in the number of copies defined by contract, covering all devices and services. All documents (including drawings) shall be supplied in searchable format. At least, the following technical documents shall be issued:

- A document with all information related to the components of the virtualized architecture including, but not limited to software version, drivers, softkeys and all related licenses. This document shall be presented to PETROBRAS at FAT and delivered, properly revised, after commissioning activities.
- Virtualization solution data book including all documents of project comprising hardware (clusters, hosts, switches etc.) and all software (hypervisor, management, and remote access software, etc.).
- Management and maintenance procedures for hardware and software platform in order keep the whole virtualized solution running properly.
- All hardware and software platform troubleshooting procedures.
- Calculation reports including load balance of CPU, RAM memory and network interface resources. These documents shall describe how each physical resource was distributed according to logical resources required by each virtual machine.
- Calculation reports explaining hardware sizing, memory allocation and description of system configuration.