Engineering Standard

SAES-P-126   31 December, 2002

Power Monitoring System

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Saudi Aramco DeskTop Standards

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1   Scope

This Standard prescribes the minimum mandatory requirements for the design and installation of Power Monitoring System (**PMS**) in industrial plants with the conditions stated in paragraph 5.1 of this standard. This document may not be attached to nor made a part of purchase orders.

2   Conflicts and Deviations

2.1   Any conflicts between this standard and other applicable Saudi Aramco Engineering Standards (SAESs), Materials System Specifications (SAMSSs), Standard Drawings (SASDs), or industry standards, codes, and forms shall be resolved in writing by the Company or Buyer Representative through the Manager, Consulting Services Department of Saudi Aramco, Dhahran.

2.2   Direct all requests to deviate from this standard in writing to the Company or Buyer Representative, who shall follow internal company procedure SAEP-302 and forward such requests to the Manager, Consulting Services Department of Saudi Aramco, Dhahran.

3   References

The selection of material and equipment, and the design, construction, maintenance, and repair of equipment and facilities covered by this standard shall comply with the latest edition of the references listed below, unless otherwise noted.

3.1   Saudi Aramco References

Saudi Aramco Engineering Procedure

SAEP-302   *Instructions for Obtaining a Waiver of a Mandatory Saudi Aramco Engineering Requirement*

Saudi Aramco Engineering Standards

SAES-P-100   *Basic Power System Design Criteria*

SAES-P-104   *Wiring Methods and Materials*

SAES-P-119   *Onshore Substations*

SAES-T-916   *Telecommunications Building Cable Systems*

Saudi Aramco Materials System Specifications

16-SAMSS-502   *Low Voltage Switchgear*

16-SAMSS-503   *Low Voltage Controlgear*

16-SAMSS-504	*Indoor Metal-Clad Switchgear: 1 to 38 kV*
16-SAMSS-506	*Indoor Controlgear – High Voltage*
16-SAMSS-507	*High Voltage Motor Controller - Outdoor*

Other Saudi Aramco Document

LAN Security	*LAN_Security_Standards_September_1994 (http://iprotect.aramco.com.sa)*

3.2   Industry Codes and Standards

Institute of Electrical and Electronics Engineers

IEEE C37.1 - 1994	*Definition, Specification, and Analysis of Systems Used for Supervisory Control, Data Acquisition, and Automatic Control*

National Fire Protection Association

NFPA 70	*National Electrical Code (NEC)*
NFPA 110	*Emergency and Standby Power Systems*

4   Definitions

AFD: Adjustable Frequency Drive.

Approval or Approved: Written approval of the ESD Coordinator.

Availability: The ratio of uptime to total time (total time = uptime plus downtime).

Client: The user point-of-entry for the required function in client/server computing. Normally, a desktop computer, workstation, or laptop computer.

Controlgear: Equipment manufactured to either 16-SAMSS-503 (Low Voltage Controlgear), 16-SAMSS-506 (High Voltage Controlgear) or 16-SAMSS-507 (High Voltage Motor Controller - Outdoor).

Database: A group of related files (data tables).

Database Management: Special software to create and maintain a database and enable individual business and application to extract the data they need without having to create separate files or data definitions in their computer programs.

DCS: Distributed Control System.

EMC: The Electromagnetic Compatibility. EMC is a measure of equipment tolerance to external electromagnetic fields.

Engineering Unit: A unit of physical measurement (e.g., Volt, Amperes).

ESD Coordinator: Coordinator, Consulting Services Department/Electrical Systems Division, Saudi Aramco, Dhahran.

Ethernet: A link layer protocol using a shared channel to broadcast messages and used widely in Aramco LAN.

Expandability: The capability of a system to be increased in capacity or provided with additional functions.

Failover: The transfer of a function or functions to a backup device.

Graphical User Interface (**GUI**): Part of a software to display data and functions. Users use graphic icons and the computer mouse to issue commands and make selections.

High Voltage: Voltages 1000 V or greater unless otherwise designated in a specific MSAER or referenced international standard.

IED: Intelligent Electronic Device. See IEEE C37.1 - 1994.

Industrial Facilities: Includes the following:

a)   Facilities directly associated with production, processing, or bulk distribution of hydrocarbons.

   This includes, but is not limited to, facilities such as the following:

   i)   Pumping or compression facilities in GOSPs

   ii)   Water injection plants

   iii)   Refineries

   iv)   Bulk distribution plants

   v)   Pumping stations

   vi)   Gas plants

   vii)   Crude Processing Facilities

b)   Hospitals

c)   Office buildings exceeding three occupied floors

d)   Control buildings

LAN: Local Area Network, a computer network that is concentrated in a geographical area such as a building or a plant area. See IEEE C37.1 - 1994.

Low Voltage: Less than 1000 V.

Monitor: The metering device; a multifunctional metering **IED**.

PMS: Power Monitoring System.

Response Time: The time between initiating some operation and obtaining results.

SAMSS: Saudi Aramco Materials System Specification.

SCADA: Supervisory Control and Data Acquisition. See IEEE C37.1 - 1994.

Scalability: The ability of a computer, product, or system to expand to serve a larger number of users without breaking down.

Server: Computer specifically optimized to provide software and other resources to other computers over a network.

Spare and **Space**: Are as described within the applicable SAMSS for Switchgear, Controlgear and Switchboards.

Substation: Per the definition within SAES-P-119.

Switchgear: Equipment manufactured to either 16-SAMSS-502 (Low Voltage Switchgear) or 16-SAMSS-504 (High Voltage Switchgear).

WAN: Wide Area Network, a computer network that spans a large geographical area and may consist of a variety of wired and microwave technologies.

Watchdog timer: A form of interval timer that is used to detect a possible malfunction.

5   General System Requirements

5.1   This standard applies on **Industrial Facilities** with the following conditions: 1) **Monitors** installed on indoor **high voltage switchgears** and indoor **high voltage controlgears**, 2) **Monitors** installed on the control and protection panel boards for transmission lines above 34.5 kV.

5.2   General Monitoring Philosophy

1)   The Power Monitoring System (**PMS**) is used throughout plant's power system to provide electrical data mainly to meet the plant needs. The plant is the custodian and the owner of the information provided by the **PMS**.

Commentary Note:

> *Organizations outside the plant can access the **PMS** using Saudi Aramco **LAN/WAN** based on **client/server** computing. It is left to the individual plants to provide an access to other organizations.*

2) Other systems such as control and protection shall not be used for, or considered in, designing the **PMS**. The **PMS** shall be separate from other critical systems such as protection and control systems.

Commentary Note:

> *The intention of this requirement is to dedicate a stand alone system for monitoring and data collection. It is allowed, and sometimes required, to interface the **PMS** with other systems such as Distributed Control System (**DCS**), protective relaying, Supervisory Control and Data Acquisition (**SCADA**) system, etc. **PMS** is considered a stand alone system even though it is allowed to be interfaced with other systems.*

5.3   Programming and Customization

1) All mandated metering functions and system setting shall be modified, disabled, and enabled without any change or modification to the hardware components of the system. Settings shall be software driven.

2) The **Database** and the **Graphical User Interface** (**GUI**) of the **PMS** shall be provided with tools to perform all required customizations and modifications.

3) The **PMS** shall have the capability to capture, manipulate, and display real-time and historical data (data logs) from different **monitors** simultaneously.

5.4   Time Synchronization and Accuracy

The time synchronization mechanism of the **PMS** shall be automatically activated every hour to synchronize system components (**server**, **database**, and field monitors). Tolerance in time differences between system clocks shall not exceed 1 millisecond.

Exception:

> *As an alternative to the requirement in 5.4.1, the Global Positioning System (GPS) clock may be used to broadcast system time to the **PMS** components.*

5.5   The Overall **availability** of the system shall not be less than 99.70%. This may require a proper use of redundant configuration and automatic **failover** techniques discussed in the IEEE C37.1 - 1994.

5.6   A minimum of 20 % of **expandability** and **scalability** is required for system hardware and software capacity. Numbers of the digital inputs/outputs on a **monitor** and memory size are examples of hardware capacity. The IEEE C37.1 - 1994 defines **expandability** and the measures to be taken to assure **expandability**.

5.7   The **Response time** when retrieving real time data using the **PMS server** shall not exceed 5 seconds.

5.8   Upon commissioning completion, the following documents shall be provided:

    5.8.1   Operating instructions shall be developed. This shall include the manufacturer documents and the user documents describing user detailed instructions.

    5.8.2   Maintenance instructions shall be provided and shall describe system performance, preventive maintenance, corrective maintenance, and spare/replaceable parts information.

    5.8.3   Provide design documentation that include wiring diagrams, layout drawings, functional block diagrams, and any related texts, photographs, and other illustrations to describe each assembly of the system.

    5.8.4   A comprehensive document shall be developed for any customizations and modifications to describe the actual (as-built) system.

    5.8.5   An electronic copy (soft copy) of the one line diagrams, frameworks, and all other customized programs shall be developed and submitted to the proponent upon final completion of the system.

5.9   **EMC** limits of the **PMS** equipment shall be in accordance to the IEEE C37.1 - 1994.

5.10   **PMS** components such as **monitors**, software, and **database** shall be provided from one vendor.

Exception:

> *With the proponent's agreement, in retrofit and upgrade projects, it is permitted to use products from different vendors provided that the overall system integrity and performance meet the minimum requirements in this standard.*

6   Communication and Networking

6.1   The **PMS** shall have a dedicated (private) **Ethernet** network that serves as communication link between the **monitors** and system **server(s)**. Design and

installation of network components shall conform to the requirements of SAES-T-916 and other applicable SAES-T standards.

Commentary Note:

> *The **PMS server** can be connected to Aramco **LAN/WAN** to provide access for **PMS clients** using Saudi Aramco network. **PMS** is considered a stand-alone system even though it is allowed to be accessed by **clients** using the public network.*

6.2   In special cases like offshore facilities and plants with remote **substations**, alternative communication means to the **Ethernet** such as serial links and modems, shall be evaluated in a case by case. In such cases, **approval** from the **ESD Coordinator** shall be obtained.

6.3   Communication network hardware components shall be powered from an Uninterruptible Power Supply (UPS) or a battery backed DC supply. The power supply to communication equipment between **monitors** and the **server** shall be maintained for a minimum of 15 minutes after interruption or loss of the normal power.

6.4   For plants with **DCS**, real-time and historical data (data logs) from **PMS** shall be made available for direct interface with the **DCS**. **Approval** from the **ESD Coordinator** shall be obtained to implement indirect interface methods such as Microsoft Dynamic Data Exchange (DDE) and/or interface with other information systems.

Commentary Note:

> *This requirement does not mean that all or any of the **PMS** data be displayed on the **DCS** shows. It is left to the plant owner to develop the **DCS** shows. Number of points and traffic load shall be reviewed to avoid overloading the **DCS**.*

6.5   The communication status to field **monitors** and **client** computers shall be monitored using a **watchdog timer** or equivalent techniques. Failures shall be logged in the **PMS database**.

7   Software, Database and Server

7.1   Computers and computer peripherals hosting main software components shall be powered from a UPS.

7.2   The **PMS** main software components shall reside in a dedicated computer (**server**).

7.3   The **PMS** shall be based on **Client** – **Server** computing technology to allow users (**clients**) access the **PMS** using Saudi Aramco **LAN/WAN**.

7.4   The security management tools of the **PMS** software shall be configured to allow for multiple access levels with different privileges.

7.5   The **Database** of the **PMS** that is consisting of more than 20 **monitors** shall reside in a dedicated computer (**database server**).

7.6   The **Graphical User Interface** (**GUI**) software component of the **PMS** shall be configured and customized with the following customizations and the proper **Engineering Units**:

Commentary Note:

> *This section prescribes the minimum requirements. More stringent customizations shall be implemented to meet plant specific requirements.*

7.6.1   An overall (simplified) diagram, on a single screen, of the plant or facility shall be developed with displays of plant total, real power, reactive power, apparent power, power factor, and system time.

7.6.2   One line diagram of monitored **substations** shall be configured with at least one screen for each **substation** displaying the following data:

   i)   Average line voltage on each bus section.

   ii)   Breaker/contactor status for each breaker/contactor.

   iii)   Average current, total real power and power factor on each feeder.

   iv)   An audible and visual alarming should immediately appear if a breaker/contactor trip. The alarm shall appear even if the screen is showing other healthy sites (screens). The alarm shall not be activated due to normal close/open operations.

7.6.3   Display(s) from each individual **monitor** shall be developed to show the following:

   i)   Phase voltages, line voltages, currents, and frequency.

   ii)   Per-phase and total of, real power, reactive power, apparent power and power factor.

   Commentary Note:

   > *The requirement of per phase voltages is not applicable when the monitors are connected to an open delta PTs.*

   iii)   Links to the **database**/memory to retrieve historical data listed in tables 1 and 2.

     iv)   Power quality related data such as harmonics, and phasor diagrams.

7.6.4   Diagram(s) for each plant process area (operating area) shall be developed with the following displays:

     i)   Electrical energy and the cost in US$ consumed for the previous two operating shifts.

     ii)   Electrical energy and the cost in US$ consumed for the previous day (yesterday).

     iii)   Electrical energy and the cost in US$ of the accumulating energy for the current operating shift.

     iv)   Electrical energy and the cost in US$ of the accumulating energy for the current day (today).

     v)   Link to retrieve historical energy data (the three shifts and the daily energy).

7.7   The **Database management** system shall be configured to perform the following tasks:

7.7.1   Automatic data backup.

7.7.2   Archive the data; data older than one year shall be automatically archived in a permanent storage media.

7.7.3   Maintain a minimum capacity of one (1) year worth of data to be always available in the online **database** (hard disk).

7.8   Data to be logged

7.8.1   Basic Parameters: See Table 1.

Table 1

Parameter	Log Interval
Phase Voltages	6 Hours
Line Voltages	6 Hours
Line Currents	6 Hours
Frequency	6 Hours
Real Power (3 Phase)	6 Hours
Reactive Power (3 Phase)	6 Hours
Apparent Power (3 Phase)	6 Hours

Power Factor (3 Phase)	6 Hours
Max. Real Power (3 Phase), Time Stamped	Every operating Shift
Min. Real Power (3 Phase), Time Stamped	Every operating Shift
Per Shift Energy	Every operating Shift
Daily Energy	Daily @ 24:00 Hours
Current THD (%)	6 Hours
Voltage THD (%)	6 Hours

7.8.2   Waveforms and Sequence of Events: See Table 2.

Table 2

Parameter*	When	Note
Breaker Open/Close	Occurrence	Time Stamped
Motor Controller Status	Occurrence	Time Stamped
Breaker Trip; e.g., Relay(s) 86 operation.	Occurrence	Time Stamped
Minimum 64 Cycles of Waveforms (Voltages and Currents), with 3 cycles of pre-event period at 32 Sample/Cycle	Voltage Sag/Swell	Set at <85% or >125% of nominal voltage. On incomer circuit breakers only. Threshold values shall be adjustable.
Minimum 10 Cycles of Waveforms (Voltages and Currents), with 3 cycles of pre-event period at 128 Sample/Cycle	Voltage Transient	Set at 135% of nominal voltage. On incomer circuit breakers only. Threshold value shall be adjustable.
Motor Start Trending, RMS values of the Voltages and Currents	Motor Start	To be triggered by breaker status. Record during motor acceleration period (0 to 100% RPM) with minimum resolution of 1 reading/125 mSec.

*   Table 2 parameters shall be time stamped to the nearest millisecond.

7.8.3   Per-process Area Data Logs

PMS shall be customized to calculate and log energy and power for each operating area (process area in the plant). Log intervals for the power and power factor shall be every six (6) hours.

7.9   A screen reporting all alarms and critical events with time stamp shall be developed. The alarms/events are listed in Table 3.

Table 3

Alarm/Event	Note
Loss of communication with field monitor	Time Stamped
Loss of communication with **DCS**	Time Stamped
Loss of communication with **database**	Time Stamped
Breaker Trip (Example: through 86 Relay)	Time Stamped
Sag/Swell and Transient Detection	Time Stamped
Loss of communication with other software modules	Time Stamped
Loss of communication with clients	Time Stamped

7.10   Retrieval of communication (back to normal event) in table 3 shall be logged
with time stamp.

7.11   When **database** engine fails, real-time data from **monitors** to **DCS** shall not be
affected.

8   Metering Devices and Installation

8.1   Metering functions shall be performed by a dedicated **monitor**. Critical
functions **IED**s such as protective devices shall not be used as monitoring
device.

8.2   Types and designations of **monitors** and software are specified in the **SAMSS**
for the **High Voltage Switchgear** and **Controlgear**.

Commentary Note:

Monitors *shall be installed on outgoing and incoming feeders only regardless of
the number of circuit breakers. For example, only one* *monitor* *shall be installed
on a 230 kV feeder in breaker and a half scheme configuration.*

8.3   LED (light emitting diode) or equivalent indication shall be provided to indicate
the following functions: (1) Unit is on (unit heart beat), (2) Communication port
operation, transmit/receive.

8.4   The **monitor**'s local display shall be configured to view parameters in Table 4:

Table 4

Parameter	Note
Phase voltages	See note 7.6.3
Line voltages	
Currents	
Per-phase real power	
Total real power	
Per-phase reactive power	
Total reactive power	
Per-phase apparent power	
Total apparent power	
Daily Energy	Meter resets automatically every day
Absolute Energy	Accumulated energy
Frequency	
Per Phase and Total PF	

8.5   The **monitor** shall be configured to support common wiring and configuration such as 2, 2-½, 3 elements including neutral voltage, current inputs, and configurable CT and PT turn ratios.

8.6   All measurement settings and configuration schemes of the **monitor** shall be software driven.

8.7   **Monitors** shall not be installed on the bus tie breakers. Breaker status and associated digital inputs of the bus tie shall be connected to the nearest **monitor** within the **switchgear**.

8.8   **Monitors** on **switchgears** shall be powered from 125 VDC. Other **monitors** can be powered from either DC or AC source.

8.9   CT, PT, and power supply termination shall incorporate isolation mean such as test switches or terminal strips. Dedicated PT fuses and dedicated CT shorting links shall be provided for the **monitors**.

8.10   Wiring and conduit installation shall conform to the installation methods prescribed in SAES-P-104.

Revision Summary
31 December, 2002   New Saudi Aramco Engineering Standard.