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# Petrobras: Real Time Quality Statistical Control applied on Reducing Emergency Shutdown events at Offshore Industry

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**AVEVA**



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# Petrobras

Petróleo Brasileiro S.A.

- Founded in 1953
- Oil & Gas Exploration, Production and Refining
- + 40.000 employees
- 13 refining plants
- 67 oil platforms

<https://petrobras.com.br/pt/quem-somos/perfil/>



# Overview of AVEVA Products used at Petrobras

## AVEVA PI System

- Collecting data since 1992
- 27 sites
- 32 AVEVA PI Servers (14 HA)
- 32 PI AF servers
- +3M tags
- 140 interfaces

## Other AVEVA Products

- AVEVA Predictive Analytics
- AVEVA Mobile Operator Round
- AVEVA Work Tasks
- AVEVA Intouch HMI
- AVEVA Operator Training Simulation
- AVEVA Pipeline Operations
- AVEVA Enterprise Crude Management
- AVEVA engineering and 3D solutions
- AVEVA marine solutions
- AVEVA simulation: process, utilities and pipeline
- AVEVA optimization: process and utilities

PETROBRAS

# Agenda

- What is an Emergency Shutdown (ESD)?
- ESD impacts on oil and gas production activities
- How we used Statistical Quality Control (SQC) to anticipate an ESD
- PI Asset Framework implementation details
- Asset monitoring at Petrobras
- Real ESD event avoided
- Questions

# Emergency Shutdown (ESD)

What is ESD?



Emergency Shutdown Systems (ESD) are **layers of protection** for industrial plants which objective is to guarantee a safe stop of systems and equipment if the limits for **safe operation** are overpassed.



**Production Losses**



**Directing people to safe areas**



**Services interruption**



**Other actions described in the emergency plan**

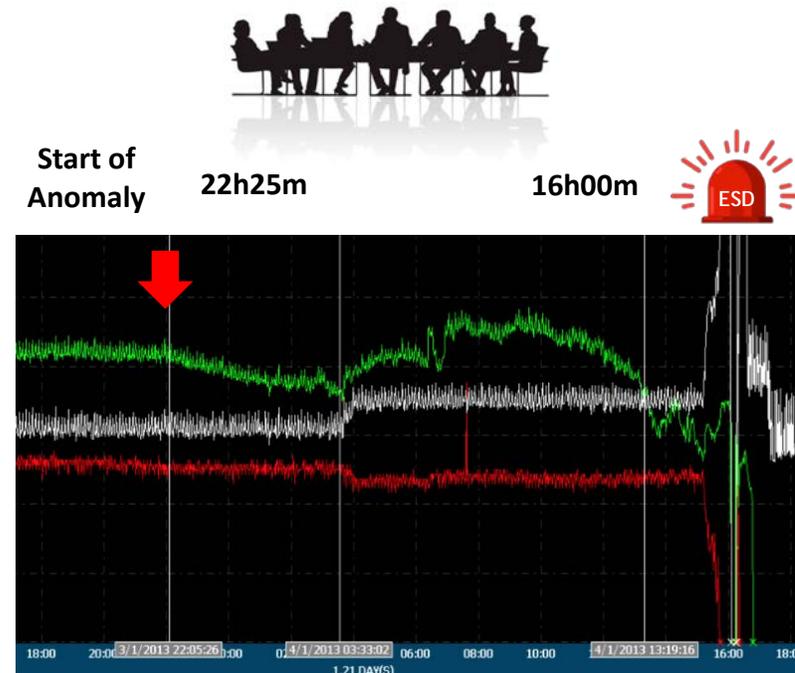
# Emergency Shutdown (ESD)

## ESD on Brazilian Oil and Gas Production

In 2018, the Emergency Shutdowns represented **38% of the 3.340 incidents** reported in activities of extraction and production of oil and natural gas in Brazilian fields submitted to ANP.



At Petrobras, we found that in some cases, the anomaly which triggered the ESD had started minutes or even hours before the event.



# ESD prediction using Statistical Quality Control (SQC)

## Internal Startup ESD Prediction

### Challenge

- Reduce ESD events;
- Improve oil production and asset reliability;
- Increase on-board crew life quality

### Solution

- Identify the variables and equipments that usually trigger ESD events;
- Develop Real Time Statistical Quality Control templates on PI Asset Framework (AF) to monitor these variables and equipments;
- Develop dashboards and alarms at our Integrity Portal – a web-based internal solution based on PI AFSDK.

### Results

- ROI - Return of Investment on the **first** avoided ESD using the **MVP** (Minimum Viable Product), with an estimated gain of **US\$ 2.2 Million**

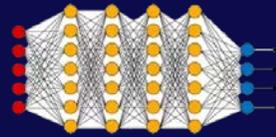


# ESD prediction using Statistical Quality Control (SQC)

## Multidisciplinary SQUAD

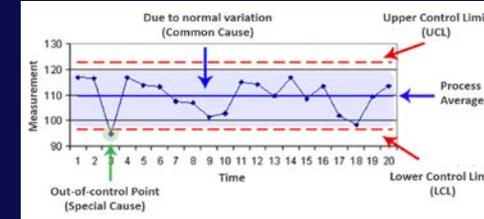


## ESD Triggers Analysis



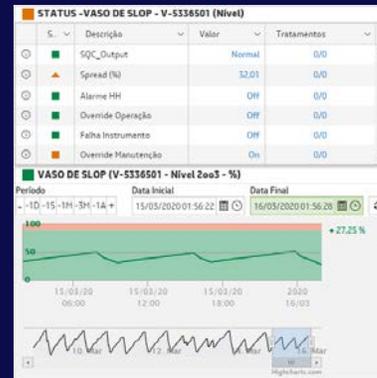
- a. Moving averages
- b. Std Deviation
- c. Upper and Lower Control Limits
- d. Spread between similar variables

## Real Time Statistical Control (SQC)



SQC Templates implemented at PI AF - Asset Framework.

## Dashboards



## Smart Alerts

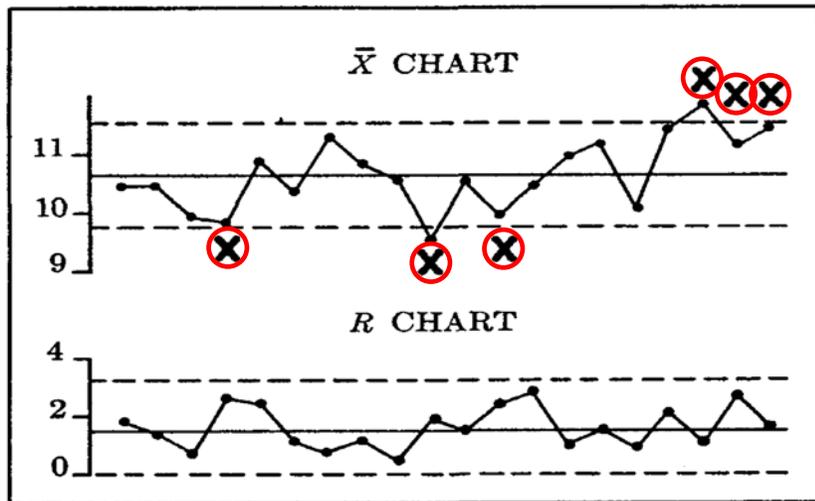
- Critical: Outside Control
- Attention: Outside 2 Sigma
- Pre-Attention: Outside 1 Sigma
- Normal: Normal

Alerts based on dynamic limits given by the SQC analysis output.

# Statistical Quality Control (SQC)

## Concepts

- Study of the characteristics of a process, with the support of **statistical data** and analysis, in order to identify **fluctuating patterns** and to **anticipate the variability of the process**.



Source: Western Electric Company. (1956). Statistical Quality Control Handbook. New York: Western Electric Company.

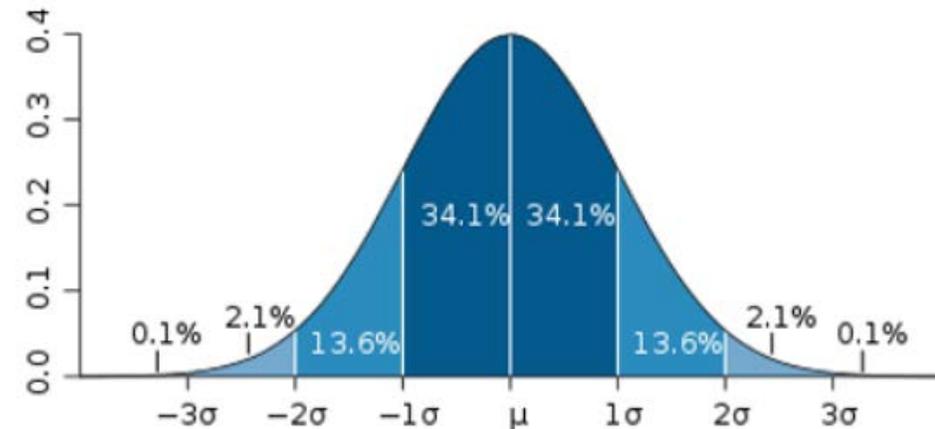
## Empirical Rule

- Statistical rule which states that for a normal distribution, almost all observed data will fall within **three standard deviations (sigma -  $\sigma$ )** of the mean or average

+/- 1 sigma = 68.2 % of population

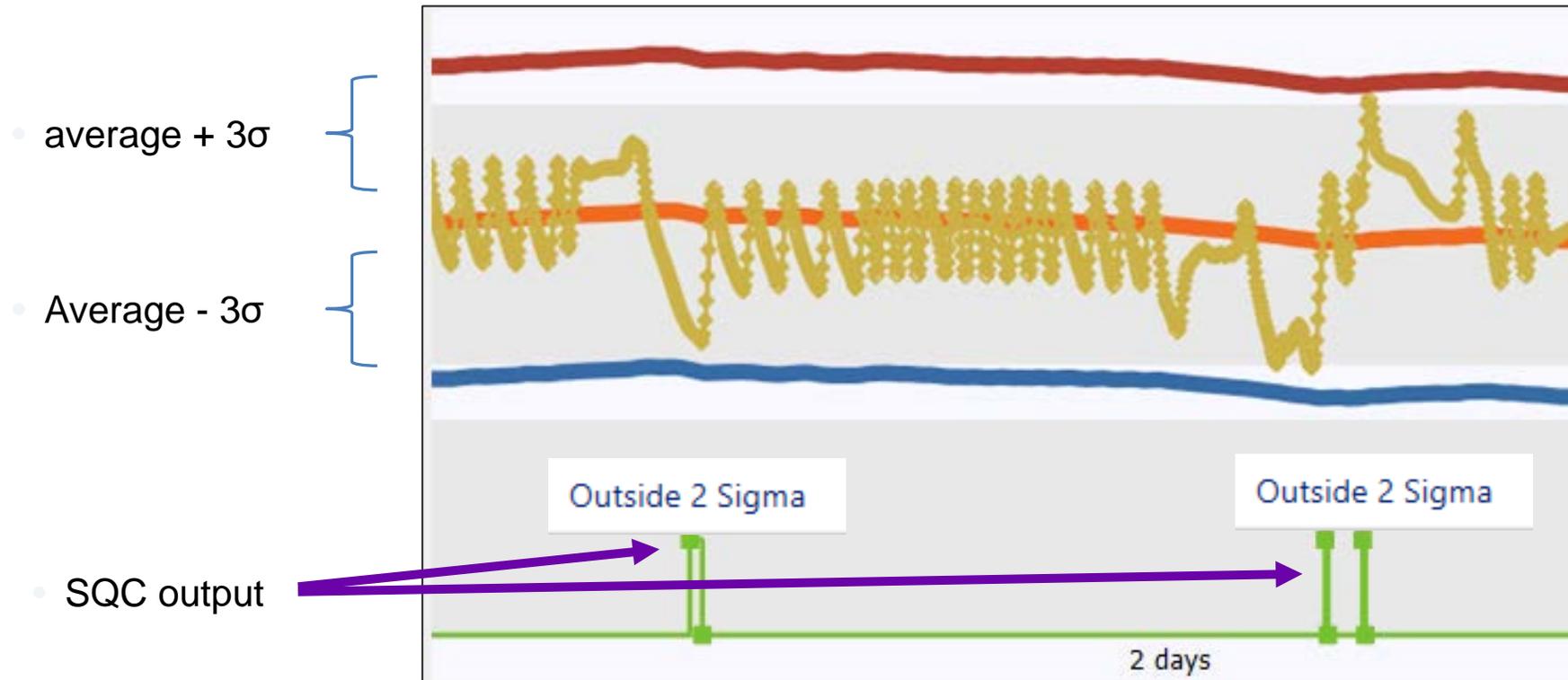
+/- 2 sigma = 95.4% of population

+/- 3 sigma = 99.7% of population



# Statistical Quality Control (SQC) in PI AF

- A solution based on **Real Time Statistical Quality Control (RTSQC)** was implemented using PI Asset Framework (PI AF) native SQC analyses to monitor critical process variables
- **Dynamic limits** based on statistical real-time data proved to be **more effective** than fixed setpoints defined in the original project.



# Statistical Quality Control (SQC) in PI AF

**PI AF Templates: +250 monitored variables**

General Attribute Templates Ports Analysis Templates Notification Rule Templates

Name: SQC  
 Description: Análise que escreve na TAG  
 Categories: SQC\_ESD2  
 Analysis Type:  Expression  Rollup  Event Frame Generation  SQC  
 Enable analyses when created from template

Example Element: [Buzios\P75\ESD2\\_Resumo\Ar Comprimido](#)

**Inputs**

Source: [Sensor em análise|Média Curta \(SQC Source\)](#)  
 Upper Control Limit: [Sensor em análise|Limite Superior](#)  
 Center Line: [Sensor em análise|Média Longa \(Linha Central\)](#)  
 Lower Control Limit: [Sensor em análise|Limite Inferior](#)

**INPUTS**

a. Source: Value to be tested  
 b. Upper Control Limit: ce  
 c. Center Line: Long mov  
 d. Lower Control Lim

**PATTERN TESTS**

a. Outside Control: . . .  
 b. Outside 2 Sigma: . . .  
 Sigma: +- 10

**SAMPLE SPACE (X of Y) AND LIMITS**

a. Fine Tuning

**Output**

Event Frame  
 AF Attribute [SQC\\_Output](#)

**SQC OUTPUT SENT TO PI DATA ARCHIVE**

Value	Name	Time Stamp	Value
0	Normal	26/03/2020 08:38:00	Normal
64	Trend	26/03/2020 08:39:00	Normal
65	Mixture	26/03/2020 08:40:00	Normal
66	Stratification	26/03/2020 08:41:00	Normal
67	OneSideOfCenterLine	26/03/2020 08:42:00	Normal
68	Outside2Sigma	26/03/2020 08:43:00	Normal
69	Outside1Sigma	26/03/2020 08:43:00	Normal
70	OutsideControl	26/03/2020 08:44:00	Normal

Value at Evaluation: Normal at 01/05/2022 11:02:17  
 Value at Last Trigger: Normal at 01/05/2022 11:02:00

# Statistical Quality Control (SQC) in PI AF

## Monitoring Spreads

In order to identify failures in measurements that could generate ESD risks, as well as diagnose the **need for sensor calibration**, an online calculation of **Spreads** was implemented.

The Spread consists of the **percentage difference** between the values indicated by the **control and trip sensors**. As a premise, it was established that Spreads greater than 10% demand the needs of risk analysis for inhibitions (override) and opening of maintenance notes.



# Monitoring SQC alarms

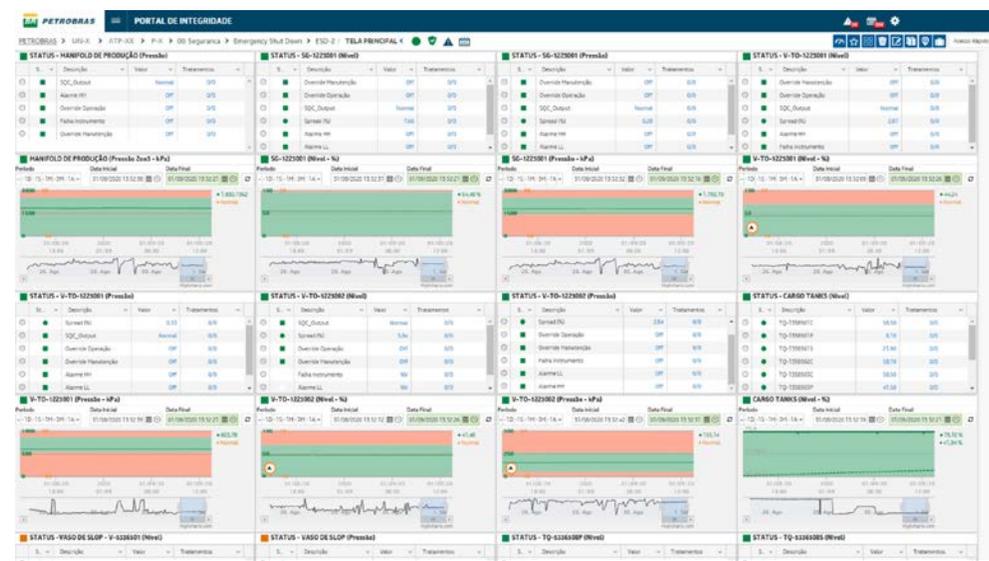
## Integrated Operations Center

- Collaborative environment for **integration** of people, work processes, and technology;
- **Real-time monitoring** and multidisciplinary decision making to reduce ESDs and increase operational efficiency.

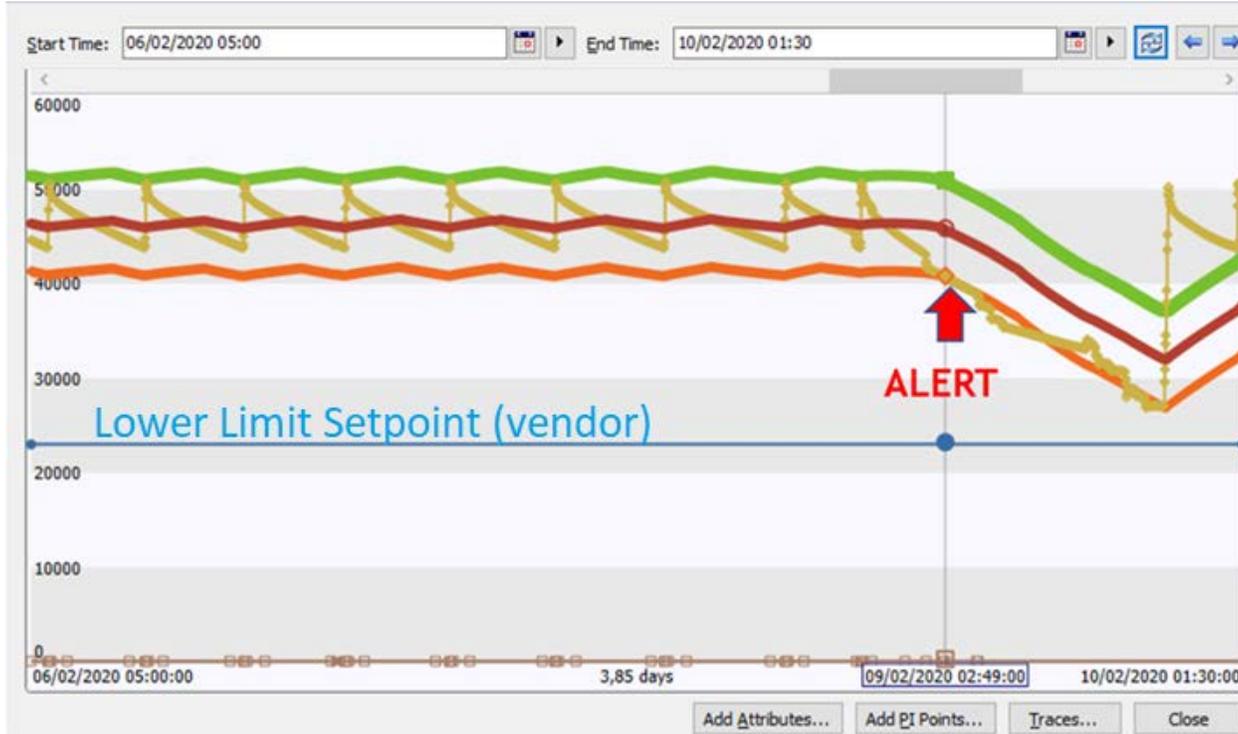


## Integrity Portal - Dashboards

- Web-based internal solution which consumes PI/AF data through PI AFSDK;
- Generates **alarms** and **events** to support our monitoring staff on taking actions based in a well-defined process;
- Custom dashboards to monitor SQC outputs, anticipating possible lack of control in the critical process variables.



# Real ESD Avoided



- HPU Subsea's pressure went to Outside Control alert at 02h49m am (pressure ~ 40600 kPa)
- Monitoring team called the operational team in order to reestablish the equipment. After several tentative, the pressure was reestablished to normal parameters;
- The variable would reach the ESD lower limit value (23000 kPa) around 11h00 pm (**23 hours later the SQC alarmed**)



**Avoided cost for the first catch**  
**US\$ 2.25M**

# ESD Prediction Startup



## Startup Results

- Value Capture: over US\$ 90 million and growing
- More than 15% reduction in ESDs\*
- Implemented in other production units

\*Including gain from other MVPs developed by the Startup.



## Challenges

- Keep reducing ESDs;
- Integrate SQC with Digital Twins models and AI solutions;
- Reduce system start-up time and the average volume of oil loss per event.



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