Fukishima Unit 2 (2F) Alarm Limits

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Agenda

- Introduction
- Alarm Limit Options
- General Procedure
- Data Requirements
- Data Used for 2F
- How the Data Was Used
- Setting the Limits
- Using the Process
- Causes for Alarms
- Future

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Introduction

- History of PEPSE at 2F
  - Units 1-4 models developed early 2008
  - Units 1-4 models tuned to plant data 2009 – design mode
- How Alarm Project Got Started
  - Discussions and alarm project definition, 2008-2009
  - Project start mid 2009
- Future
  - Units 1-4 models tuned to plant data 2010 – perf mode
  - 2F Unit 1 alarms after turbine replacement

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Alarm Limit Options

- **Limits Based on Plant Experience and Knowledge**
  - Arbitrary
  - Vary from plant to plant
- **Limits Based on 1st Principles**
  - Design mode components
  - Use design mode tuning factors
- **Limits Based on Historical Data**
  - Over time
  - Averages, min/max, statistical, other

General Procedure

- Build PEPSE Models
- Collect Data (1 month -> 2 years)
- Review Data for Applicability
- Define Average or Trend
  - Average for static data
  - Trend for varying data
- Establish Alarm Limits
- Define Procedure for Use

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PEPSE Models

- 2F Units 1-4 Developed in January/February 2008
  - Heat balance models
  - Models tuned to acceptance test data
  - Models with design mode components
- Models Modified for This Effort
  - Used models tuned to acceptance test data
  - Modified models using turbines tuned to plant data
  - Added additional “Special Outputs” to reflect stage pressure ratios

Data Requirements

- **Types of Data - P, T, MWe, MWt, flows**
- **Hardware**
  - **Turbines**
  - **Feedwater heaters and condensers**
  - **Pumps**
  - **Generator**
  - **Moisture separators and reheaters**
- **Amount – 2 years**
- **Accuracy (?)**

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Data Used for 2F

- **What We Used**
  - 24 months, 2 timestamps/month (7/31/07 – 7/31/09)
  - 100+ tags/unit
- **What We Didn't Use**
  - Redundant tags
  - Bad data
  - Not required for PEPSE
  - Averages

How the Data Was Used

- **Process**
  - **Used data to calculate performance parameters (TTD, DCA, ΔT, P_1/P_2, backpressure, cleanliness factor, final feed T, pump power and head, MWe)**
  - **Excel used to manage data**

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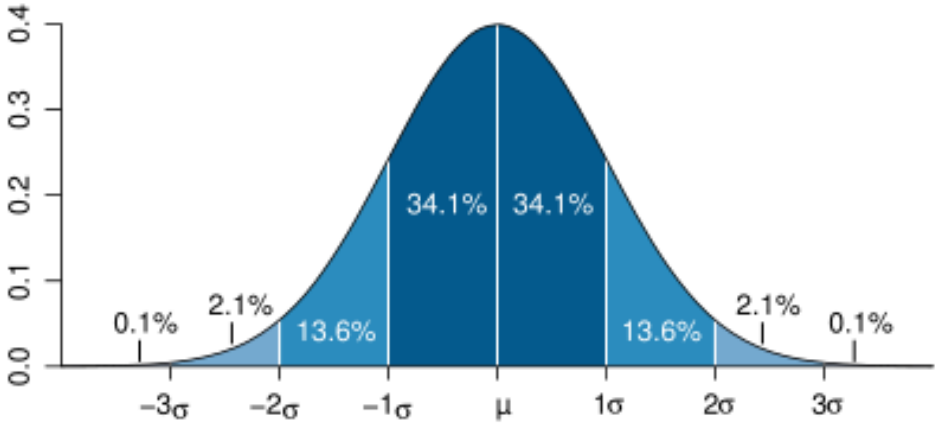
Setting the Limits

- Methods Reviewed and Approach Chosen
  - Statistics Method Recommended and Approved
  - 3σ Approach Used



Setting the Limits (cont.)

- **Static – Uses Average of Sample for Baseline**

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}[x_i - \bar{x}]^2}$$

where: σ = 1 standard deviation

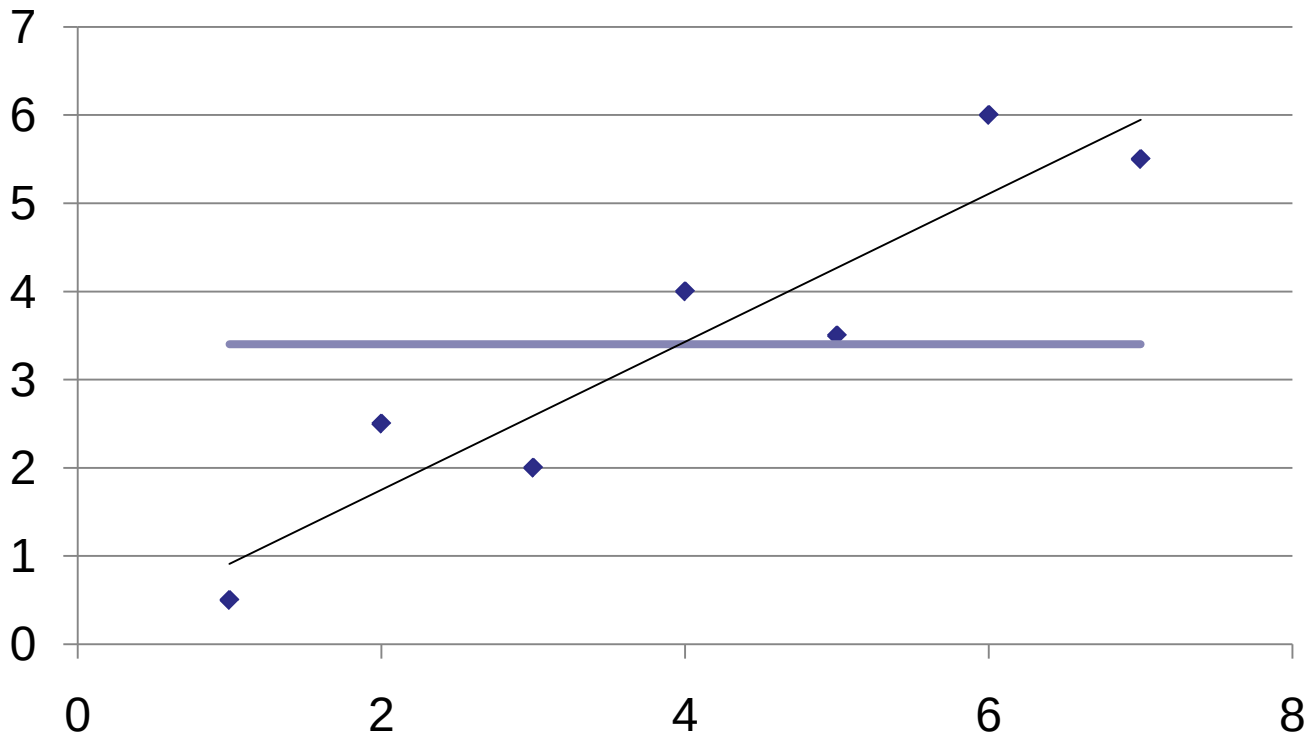
N = number of data points in sample

x_i = each data point

$\bar{x}$ = average of data sample

Setting the Limits (cont.)

- Varying



Setting the Limits (cont.)

- **Varying – Uses Trendline (2nd Order) as Baseline**

$$\sigma = \sqrt{\frac{1}{N-1-k}\sum_{i=1}^{N}[x_i - f(y_i)]^2}$$

where: k = order of polynomial

$f(y_i)$ = trend line function of order *k*

Other parameters same as static

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Setting the Limits (cont.)

- Large spreadsheet to manage 2-year's data
- Most data static
- Dynamic data varied with circulating water temperature (condenser backpressure)

Using the Process

- **Transfer Alarm Limits to Separate Spreadsheet**
  - Separate spreadsheet used to monitor data
  - Calculated alarm limits transferred automatically to monitoring spreadsheet - “Modeling_u3.xls” (for Unit 3)
- **Changing the Alarm Limits**
  - Recalculate limits using new data set
  - Manually change limits on spreadsheet

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Causes for Alarms

- Bad Data
  - Instrumentation failure
  - Drift
- Malfunctioning Components
  - Degraded over time
  - Step change
- Plant Transient
- Data Frequency or Time Mismatch
- Limits Too Tight

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Future

- Alarm Limits for 1F
  - 2F or Scientech
  - Duration of data (1 day -> 2 years)
- PMAX
- Discussion

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Questions?

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Scientech History and Experience

- **PEPSE**
  - Started 1978
  - 200+ installations worldwide in 20 countries
  - Every nuclear plant in US
  - Many fossil installations
- **PMAX**
  - Started in 1983
  - 250 installations worldwide in 8 countries
  - 60% of US nuclear plants
  - Many fossil installations