EFCOG Best Practice #107

Title: Recommended Structure for System Health Monitoring and Reporting

Facility: Multiple

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Brief Description of Best Practice: This best practice provides a proposed outline and details of what is recommended for *System Heath Monitoring and Reporting* for systems that fall under the Cognizant System Engineering portion of DOE O420.*1B/1C*, ***Facility Safety***. System Health monitoring is a key step to assure that the system is fulfilling its required functions. Formal reporting is normally completed on a periodic basis (from quarterly to annually depending on the nature of the system being evaluated) and provides a tool for the Cognizant System Engineer to communicate status, issues or opportunities.

Why the best practice was used: The Engineering Practices Working Group, System Engineering Subgroup, identified a need to develop guidance that could be considered across the DOE complex to supplement DOE O 420.1B discussion of monitoring and reporting system heath. The Attached outline has successfully been implemented at several of the larger operating nuclear facilities.

What are the benefits of the best practice: Consistency in approach across facilities at a site in terms of the how to evaluate system health improves ability to cross train staff, as well as providing an improved format to facilitate review by management. If a consistent structure and approach is used, the Facility and Engineering management become familiar with the structure and can more quickly identify trends and find needed information.

What problems/issues were associated with the best practice: Different engineers often structure data and reports differently and do not see the advantage of consistent formats (or believe their format is an improvement over others). Also there has been pushback by some regarding the approach and level of detail expected in System Health monitoring. Several revisions of this outline were evaluated before the System Engineering subgroup members selected the elements and level of detail recommended.

How the success of the Best Practice was measured: Success is measured by groups that have started to use the recommended format and approach across the complex, based on input on the draft format (attached).

Description of process experience using the Best Practice: The attached proposed approach was developed by the System Engineering Subgroup of the EFCOG Engineering Practices Working Group. It was based on expert input from the majority of the DOE sites that have active system under the requirements of DOE O 420.1B. It was developed based on the identified need to have guidance to the Cognizant System Engineers regarding the expected approach to monitor system health. The format and approach chosen is based on successful implementation at facilities that have been reviewed by external agencies.

ISMS Core Function: Provide Feedback and improvements.

1 Introduction

1.1 Purpose

This guidance provides direction for the identification, testing, collection, and analysis of performance data for Structures, Systems and Components (SSCs). This system health monitoring is performed in order to improve the reliability and availability of SSCs through early detection of degradation. Early detection of SSC degradation results in better planning and scheduling of maintenance work, which further results in a significant improvement in predictive and preventive maintenance, better use of manpower, improved reliability of SSCs, and an improved spare parts program.

1.2 Scope

This guidance applies to the Cognizant System Engineers (CSE) and design authority personnel who are responsible for monitoring system performance to ensure system availability, reliability, and maintainability. The primary focus is on application to active safety systems credited in the approved safety analysis. Due to the potential benefits of active system health monitoring, the owners of process equipment, support systems, and facilities may request and sponsor the application of this process on additional systems. When identifying additional systems, particularly those which may not be classified as a Vital Safety System, the applicable CSE(s) should be consulted. (Section 2.2 provides additional application guidance.)

1.3 Terminology

Reliability – The ability of an SSC to perform a required function under stated conditions for a period of time

Availability – The ability of an SSC to perform its required function at a stated instant of time over a stated period of time

Maintainability – The ability of an SSC, under stated conditions of use, to be retained in, or restored to, a state in which it can perform its required function, when maintenance is performed properly

Operability - the ability of an SSC to perform its required function when all necessary attendant instrumentation, controls, electrical power, cooling water, lubrication, and other auxiliary equipment required perform their related function

Cognizant System Engineer – the qualified system engineer, typically from the design authority organization, assigned to the VSS for the purpose of maintaining and monitoring. For some sites the CSE and the design authority roles may be combined.

1.4 Overview

System Health Monitoring is an essential element of the equipment reliability process and should be included as an element for the management of Vital Safety Systems (VSSs). Systems Health Monitoring provides the CSEs and the equipment owners with the means to easily assess the current and historical performance of systems to ascertain SSC maintainability, reliability, availability, and operability. Through systems health monitoring, potential equipment malfunctions can be detected, often allowing for corrective actions to be taken prior to a failure. This in turn can save money in costly replacement parts as well as increasing the availability and reliability of the equipment.

A simple representation of how system health monitoring integrates into the review and reporting processes for VSSs is provided in Figure 1 . Surveillance requirements are defined by the safety basis and are intended to demonstrate the operability at a period of time. These surveillances typically include calibration(s) and/or functional test(s). Assessments are periodically performed to evaluate compliance to stated requirements or procedures. For VSSs, a configuration management assessment can include a comparison of the field condition against design output documents such as drawings.

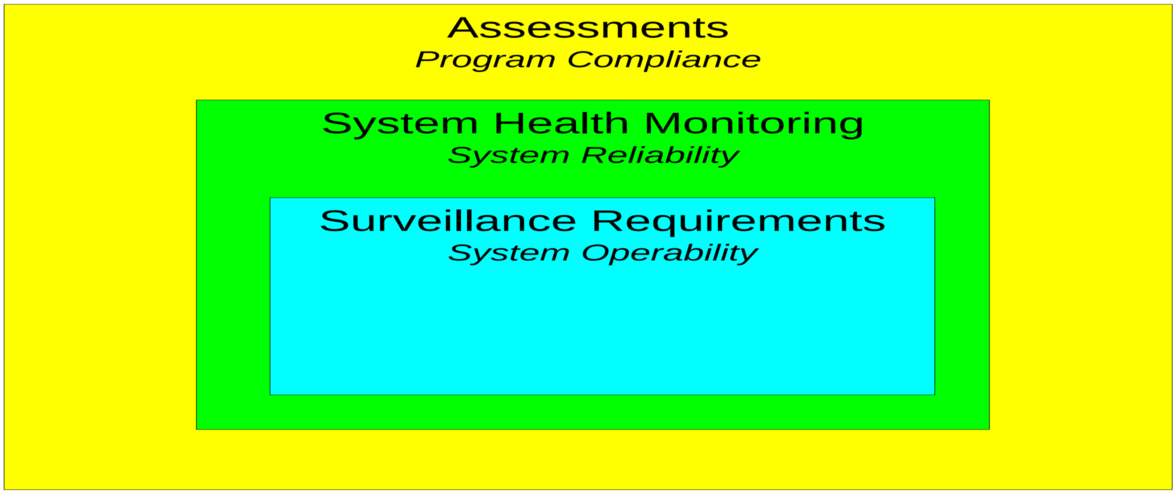


Figure 1 VSS Program elements which can develop a report.

This guidance provides the general responsibilities and instruction for SSC performance monitoring. It is not intended to provide detailed instructions on how to perform monitoring for every type of VSSs within the DOE Complex or define a management structure for VSS programs. Specific application may be tailored, within the framework described herein, based upon the specific SSC being monitored, facility being supported, operational needs, or owner's request. Figure 2 provides a simplified flow chart showing the primary steps of the system health monitoring process.

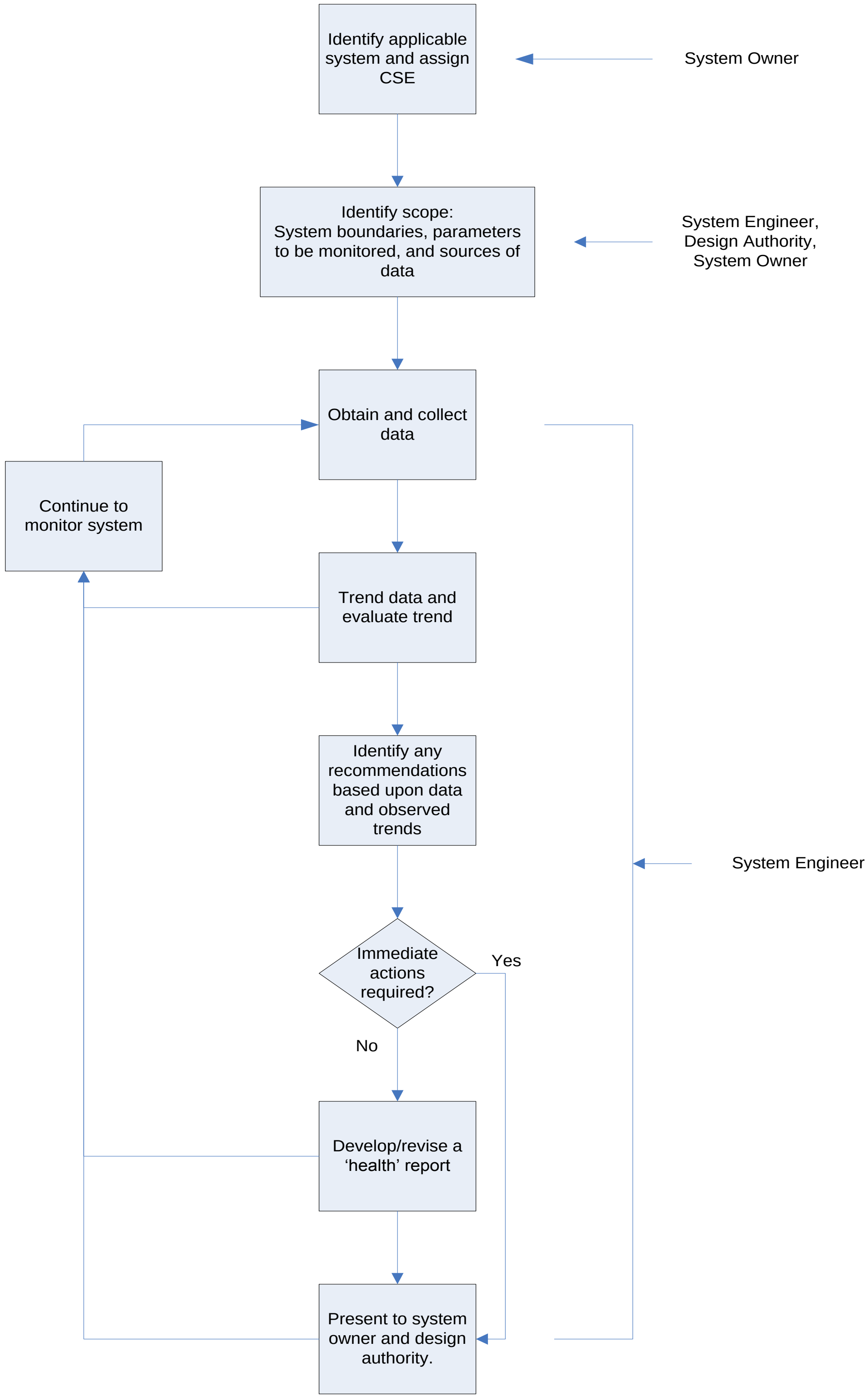


Figure 2 Basic steps of a system health monitoring process.

2 Process

2.1 Roles and Responsibilities

2.1.1 Operations Management

- Sets priorities necessary to achieve mission required availability of SSCs
- Reviews system health reports
- Commits resources necessary for corrective actions based on performance monitoring results

2.1.2 Design Authority

- Works with CSE to identify SSCs to monitor
- Works with CSE to identify performance indicators for each SSC
- Selects applicable CSE to perform SSC performance monitoring
- Reviews SSC monitoring results

2.1.3 Cognizant System Engineer

- Defines performance monitoring activities, parameters, and criteria
- Defines the boundaries and/or interfaces of the SSC
- Initiates design modifications as necessary to obtain data
- Obtains applicable SSC performance monitoring data (calibration, preventative maintenance, equipment testing and inspection, walkdown observations, surveillances, and other applicable information), initiates, and maintains applicable trending information
- Recommends corrective actions based on SSC monitored parameters
- Prepares System Health Reports
- Presents results of SSC analysis to operations management upon request
- Tracks results of trending, monitoring, and recommendations
- Delegates SSC monitoring responsibilities to a Technical Agency, as needed
- Performs periodic walkdowns to evaluate system for configuration and degradation

2.1.4 Maintenance & Operations Personnel

- Assists the CSE in collecting and analyzing SSC performance data

2.2 Identification of Monitoring Needs

The CSE and the design authority, identifies SSCs to monitor and ensures that characteristics exist that may be monitored to effectively meet the SSC monitoring objectives.

2.2.1 SSCs to be Monitored

System health monitoring provides a real time monitor of SSC performance to provide feedback to the system owner of potential reliability and availability concerns. It is recommended that the process be applied to SSCs designated as vital safety systems but benefit may also be derived if applied to other systems which may not be safety related. The system owner can consider the following characteristics for the need of performing health monitoring:

- Impact of partial or complete system failure upon mission or operation of other systems or facilities
- Past problems related to this system
- System interactions with other systems
- Impact of reduced system performance
- Cost to repair or replace
- Critical project SSCs in support of system level/startup testing
- SSCs to maintain compliance with licenses/permits

2.2.2 Identification of Attributes to be Monitored

The CSE is responsible for identifying the parameters to be monitored and the schedule for periodically monitoring. The required safety function parameters and surveillance requirements identified in the safety basis should serve as the primary source of input for characteristics to be monitored. The following should be considered and trended based upon the information available:

- Calibration data
  - Comparing as-found to the required value
- Functional testing
  - Response Time, actual vs. required
- Other safety function requirements
  - Leak testing
  - Operator workarounds that affect ability to operate equipment
  - Number of annunciators in alarm
  - Lost capacity caused by failures of components
  - Frequency of specific/recurring failures per year
- Performance of maintenance activities
  - Open corrective maintenance
  - Required preventative maintenance status
    - Overdue
    - Deferrals
- Status of modifications
  - Number of temporary modifications
  - Proposed modifications which have not been implemented
  - Outstanding actions from implemented changes

2.2.3 Periodic Walkdowns of SSC

The CSE should coordinate and perform walkdowns of the SSC on a periodic basis to evaluate system for potential signs of degradation and for configuration changes. It is recommended a full system walkdown be performed at least annually if the system has been in service; for large or multiple systems they can be divided in order to perform more frequent, narrow scope walkdowns. A team approach is recommended to incorporate other disciplines and additional experience to evaluate the field configuration, consideration of representatives from the Design Authority organization, safety professionals, other system engineers, and personnel from site oversight (NNSA/DOE) to participate on the walkdown.

2.3 SSC Performance Reporting Activities

NOTE: If at any stage during the process of SSC performance monitoring it is observed that an SSC parameter or condition may affect safe or reliable operation or have the potential to endanger personnel or equipment, the CSE shall immediately notify the appropriate Operations personnel.

The CSE should initiate the appropriate actions to implement the monitoring activities including coordinating performance monitoring tests with other plant programs (e.g., surveillance testing and preventive maintenance) so that testing is not duplicated. The obtained data shall be evaluated for any potential trends or negative results. After reviewing the results, the CSE identifies areas where improvement is needed, and will make recommendations, with justifications, in final report. A summary of the report shall be presented early in the report which provides a quick identification of the results and trends, an example summary table is presented in Attachment 1.

The collected data should be collected in a format that is readily retrievable for use by the CSE for identifying any potential trends. The use of common software tools such as a spreadsheet or database is recommended due to ease to input data and use sharing with other personnel within the facility. Spreadsheet software allows for the presentation of the data in both tabular and graphical forms which can be imported into a report. (Sample tables are provided in Attachment 2.) The data results shall be compared against acceptance criteria to easily identify if there is a trend to a potential failure condition. The graphical form also provides a quick summary view of the collected data.

Caution should be taken to understand how the data is being collected and recorded to ensure it is trended and evaluated consistently in the system health report.

- If calibration data is being trended the drift during a calibration period should be compared against the ‘as-left’ value of the previous calibration to the ‘as-found’ value of the current calibration.
- If a repair is made or component is replaced it should be clearly identified in the report and its potential effects on previously collected data.
- If several data points are collected over surveillance periods with inconsistent durations the graphical trend should be presented in a scatter graph format or adjusted for the different durations.

The CSE documents SSC monitoring results in a summary report in accordance with the facility SSC monitoring schedule. An example report table of contents is provided in Attachment 3. These schedules will be set by the CSE with concurrence from the DAR. The schedule should primarily be based upon the specified surveillance frequencies of equipment monitored and the capability to provide a measurable feedback on SSC performance. Examples: If the equipment is only calibrated annually, then an annual report can be considered. If the equipment is calibrated annually but also include quarterly functional tests, then a quarterly report should be used to trend and evaluate the performance. The CSE can include a recommendation and justification in the report to increase the evaluation period.

The Operations Management reviews the report and provides the necessary resources and for the recommended follow-up actions to be implemented and/or make additional suggestions as applicable. The CSE ensures tracking, implementation, and closure of approved follow-up actions.

Attachment 1 – Example of Summary Results Presentation

SYSTEM RATINGS and TRENDS				
Category	**FY11 Q3**	**FY11 Q2**	**Goal**	**Trend**
Availability (Overall)	95.9%	98.2%	> 95%	↓
Availability (Safety SSC)	99.6%	99.7%	> 95%	↓
Reliability	EXCEPTIONAL	EXCEPTIONAL	EXCEPTIONAL	↑
Component Failures (Major)	0	0	≤ 2	↔
Open Corrective Maintenance Work Packages (Overall) [1]	6	10	IMPROVING TREND	↑
Significant CRRS [2]	2	2	0	↔
System CRRS (Others)[2]	3	8	< 20	↑
Overdue Preventive Maintenance [3]	8	4		↓
Regulatory Issues	1	1		↔

Attachment 2 – Example of Data Presentation

Summary of Surveillance Acceptance

Table X: Results for SR X.X.X.X

Date Completed	Result	Days Between Completion	Within OSR Frequency	Within OSR Grace Period
8/3/2004	SAT			
11/2/2004	SAT	91	YES	YES
2/16/2005	SAT	106	NO	YES
5/17/2005	SAT	90	YES	YES
8/22/2005	SAT	97	NO	YES
11/22/2005	SAT	92	YES	YES
3/16/2006	SAT	114	NO	YES
6/19/2006	SAT	95	NO	YES
6/13/2007	SAT	359	NO	NO

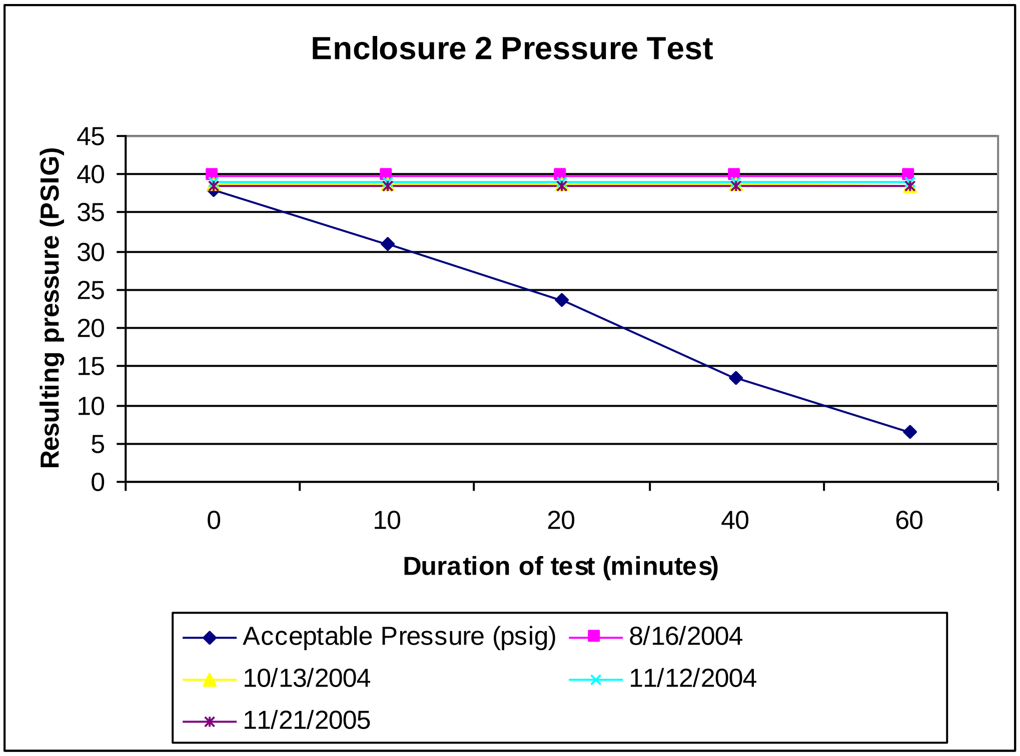
Table X: Response Time Results for SR X.X.X.X

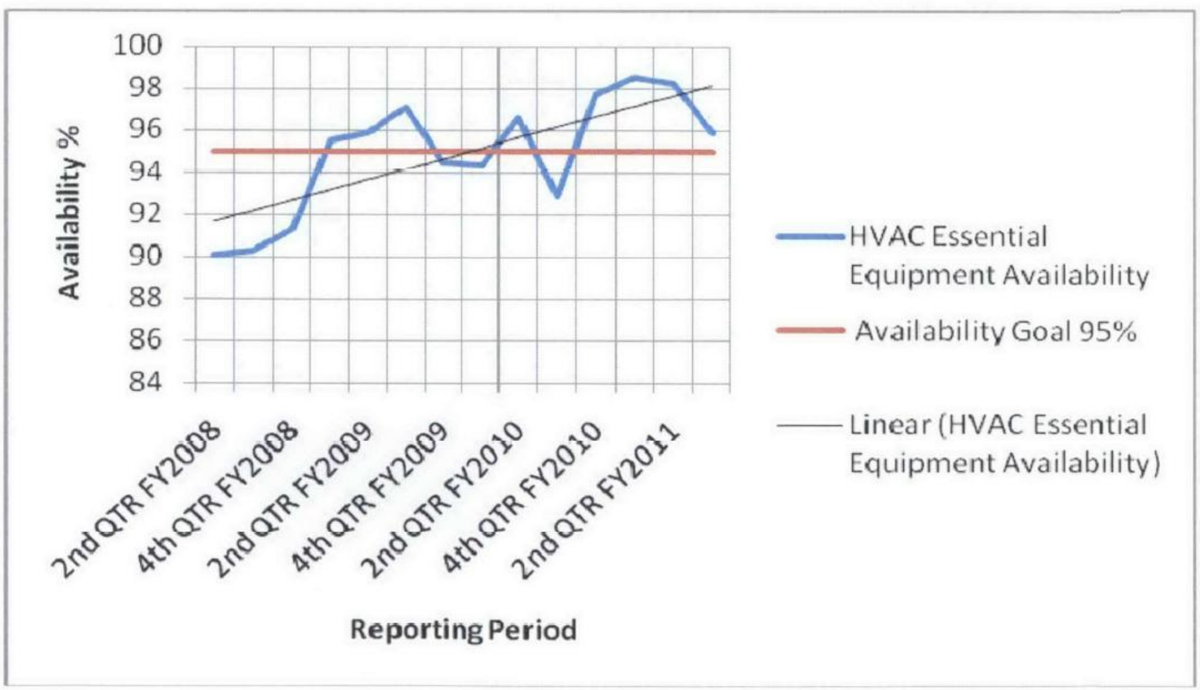
Date Completed	Interlock Tested	Component	Required Action	Required Response	Actual Response
6/13/2007	PSL-139	HV-103	Close	<14 sec	2 sec
		HV-110	Close	<14 sec	2 sec
6/13/2007	PT-213	HV-203	Close	<14 sec	5 sec
		HV-223	Close	<14 sec	6 sec
		HV-226	Close	<14 sec	6 sec
6/13/2007	PSH-146	HV-103	Close	<14 sec	3 sec
		HV-110	Close	<14 sec	3 sec

Table XX: Pressure Decay Results for SR X.X.X.X

Valves Checked	Time (min)	Acceptable Pressure (psig)	Pressure (psig)			
			8/16/04	10/13/04	11/12/04	11/21/05
Enclosure 1	0	19-21	19.03	19.20	19.58	19.66
	5	15.7	19.03	19.26	19.58	19.66
	10	10.8	19.03	19.26	19.58	19.66
	20	4.2	19.03	19.25	19.58	19.66
	60	0.0	19.05	19.24	19.57	19.63
Enclosure 2	0	38-39.2/40	39.81	38.78	39.05	38.5
	10	31.0	39.77	38.74	39.03	38.45
	20	23.8	39.76	38.71	39.00	38.43
	40	13.4	39.75	38.66	38.97	38.41
	60	6.6	39.75	38.61	38.93	38.39

Or in graphical form





Presentation of measuring the system availability against a prescribed goal.

Table X: Status of Open Corrective Maintenance

Date	Notification or Work Order Number	Description	Affect on System	Status as of Last Report	Status as of [DATE]	Expected Closure

Table A2: History of Results for Calibration of One Point (Pressure Switch)

Date Completed	Days Between Completion	Within OSR Freq	Input (psig)	As Found	Low Limit	High Limit	In Cal	Low Adj	High Adj	In Adj	As Left
7/7/2005			15.5	15.138	14.64	16.36	YES	15	16	YES	15.138
7/6/2006	364	YES	15.5	14.94	14.64	16.36	YES	15	16	NO	15.43
5/10/2007	308	YES	15.5	15.26	14.64	16.36	YES	15	16	YES	15.26

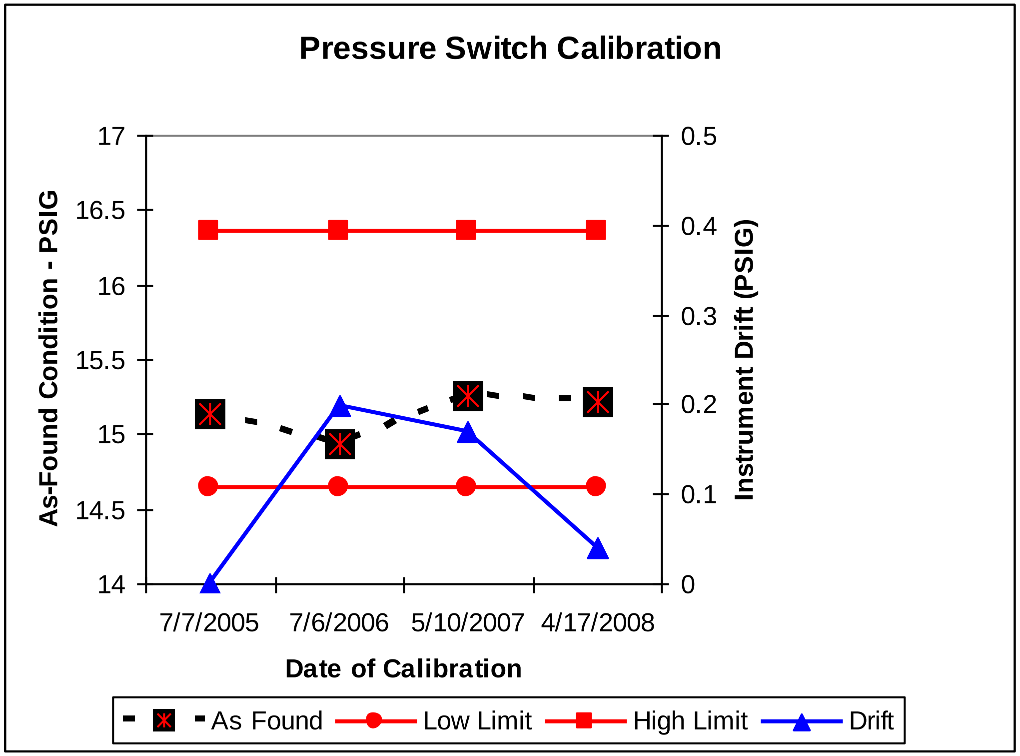


Table A4: History of Results for Calibration of Full Range Device

Date Completed	Days Between Completion	Within OSR Freq	Input (mA)	As Found	Low Limit	High Limit	In Cal	Low Adj	High Adj	In Adj	As Left
6/7/2005			4	4.004	3.828	4.172	YES	3.835	4.165	YES	4.004
			8	8.000	7.828	8.172	YES	7.835	8.165	YES	8.000
			12	11.991	11.828	12.172	YES	11.835	12.165	YES	11.991
			16	15.985	15.828	16.172	YES	15.835	16.165	YES	15.985
			20	20.000	19.828	20.172	YES	19.835	20.165	YES	20.000
			16	15.992	15.828	16.172	YES	15.835	16.165	YES	15.992
			12	11.998	11.828	12.172	YES	11.835	12.165	YES	11.998
			8	7.998	7.828	8.172	YES	7.835	8.165	YES	7.998
			4	4.004	3.828	4.172	YES	3.835	4.165	YES	4.004

Attachment 3– Example Table of Contents Example

Content

1. Introduction
2. Summary of Results
3. OSR Surveillances
    - 3.1. SR X.Y.1.1 –Pressure Interlocks
    - 3.2. SR X.Y.1.1 –Functional Test XXYY
    - 3.3. SR X.Y.1.1 –Pressure or Leak Test of XXYY
    - 3.4. SR X.Y.1.2 - System Interlock
4. OSR Credited Calibrations
    - 4.1. {UNID} – Name and function of component being calibrated
    - 4.2. {UNID} – Name and function of component being calibrated
    - 4.3. {UNID} – Name and function of component being calibrated
5. Open Corrective Maintenance Items
6. System Notes/Walkdowns
7. Summary of current and previous walkdowns