出國報告（出國類別：其他）

# 赴美國佛羅里達參加 2015「EQ Technical Meeting(EQTM)」研討會出國報告

服務機關：核能研究所
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派赴國家：美國
出國期間：104 年 10 月 31 日~104 年 11 月 9 日
報告日期：104 年 12 月 9 日

摘　要

「第二十七屆設備驗證技術研討會」(27th Equipment Qualification Technical Meeting)由 Curtiss-Wright 公司於 2015 年 11 月 4 至 11 月 6 日在美國佛羅里達州清水市舉行。來自全球各地核電廠的 EQ 工程師或核電業者，參加唯一與嚴酷環境之設備驗證相關技術交流的研討會。於研討會舉行之前，11 月 2 至 11 月 3 日 Curtiss-Wright 公司亦舉辦「Advanced EQ Training Course」，本年度之訓練課程為 Temperature Monitoring，本訓練課程係介紹①溫度監測方案之源起，②美國核能管制單位(USNRC)之法規要求，③USNRC 過去所發布與溫度監測方案有關的 Information Notice，④提供如何規劃溫度監測、工具與方法、資料處理與應用、以及如何製作文件等。Temperature Monitoring 訓練課對於本所執行核電廠電纜及連接組件絕緣狀況現場巡查以及核電廠時限整體安全評估之時限老化分析作業多所助益。

在環境溫度監測方面，如果安裝溫度監測以前，該環境未有任何 Design change/Power change 等，可合理假設該環境未曾發生環境變化，引用溫度監測後之溫度數據，但要有合理的評估。關於組件壽命重新評估時之熱老化溫度需加上多少餘裕(Margin)溫度，舉例來說，若是提高 margin 到 10℃，組件壽命會縮短一半，更換周期亦會縮短，對業界而言，會增加成本。相關訊息可參考 IEEE 323 建議之 margin 值。

環境設備的驗證與壽命評估一直是國內核電廠的重要工作，因此未來應持續參與嚴酷環境之設備驗證相關技術交流的研討會，多與美國業界人員交流。

# 目　次

# 一、 目的

核能電廠運轉安全長期受到各界關注，自從日本福島事故後，又瞬間成為全球關心的焦點。國內核能電廠的安全當然也受到民眾高度重視，而其中良好的設備維護，對核能機組安全具有關鍵性的影響。核能電廠安全相關結構、系統及組件所使用的核能級產品，其主要功能為確保：(1)反應器冷卻水壓力邊界之完整性；(2)反應器停機並處於安全停機狀況；(3)放射性物質外洩量不超出法規限值。因此這些核能級產品都必須經過嚴格的驗證與品保程序，產生並維持完整的驗證文件，證明其能發揮安全功能。

本項研討會舉行的目的，希望能藉由核能技術與運轉經驗的持續密切交流，以提昇核能電廠的安全性與穩定性。本次研討會共分成訓練與研討會二部份，詳細內容如下表一所示。有將兩百多位學者參與盛會，內容從經驗分享到理論的研究都涵蓋在內。

本所執行「核一廠西屋 TYPE-W 馬達控制中心驗證工作」計畫，參加 2015 年「Advance EQ Training Course」內容包含完整 EQ 環境驗證訓練課程，可有效提升本所檢證中心之環境驗證技術。另外，同地點舉辦「EQ Technical Meeting(EQTM)」提供與國外專家經驗交流之研討會，對於目前福島事故後 EQ 組件環境驗證相關議題、國外管制單位對 EQ 環境驗證之法規發展現況等進行交流。

因楊智堯與李耀民亦參與「核一、二、三廠時限整體安全評估(IPA)計畫」，負責 Environmental Qualification(EQ)及電氣組件之評估作業，所以參加 2015 年「EQ Technical Meeting(EQTM)」及「Advance EQ Training Course」對於目前國內核能電廠電氣設備環境驗證、壽命評

估與設備老化管理評估作業均有所幫助。

表一：EQTM 的討論議題

| | |
|---|---|
| Monday - Tuesday,<br>November 2-3 | Training (Optional)<br>Subject: Temperature Monitoring |
| Tuesday, November 3 | EQMS Users Group |
| Wednesday, November 4 | Industry EQ Initiatives<br>EQ Technical Topics<br>EQ Program Topics |
| Thursday, November 5 | EQ Topics<br>Regulatory Developments<br>Utility Interactions – Plant Topics |
| Friday, November 6 | Utility Interactions – EQ Program<br>Performance Utility<br>Interactions – Plant Topics |

# 二、 過程

| 日期 | 起迄地點 | 概要說明 |
| --- | --- | --- |
| 10月31日-11月1日 | 桃園→佛羅里達州清水市 | 去程 |
| 11月2-3日 | 佛羅里達州清水市 | Advanced EQ Training Course |
| 11月4-6日 | 佛羅里達州清水市 | 27th Equipment Qualification Technical Meeting |
| 11月7-9日 | 佛羅里達州清水市→桃園 | 返回桃園 |

「第二十七屆設備驗證技術研討會」(27th Equipment Qualification Technical Meeting)由 Curtiss-Wright 公司舉行。在研討會之前，11 月 2 至 11 月 3 日 Curtiss-Wright 公司先舉辦「Advanced EQ Training Course」課程。因為溫度監測係環境驗證方案的重要工作之一，因此在「Advanced EQ Training Course」課程中大部分時間都針對此議題進行討論。

溫度監測大多使用於 EQ 方案，可由下列一或多個方式組成，(1) One-Time or Discrete monitoring；(2) Periodic or Repetitive monitoring；(3) Continuous monitoring。溫度監測可應用於電廠區域、設備以及電纜與群組組件。主要使用的理由包含:(1)證明實際運轉溫度在設計或分析值內；(2)解釋實際運轉溫度狀態；(3)確認局部熱點或不良的溫度環境；(4)作為評估 EQ 組件驗證壽命回饋機制的一部分。

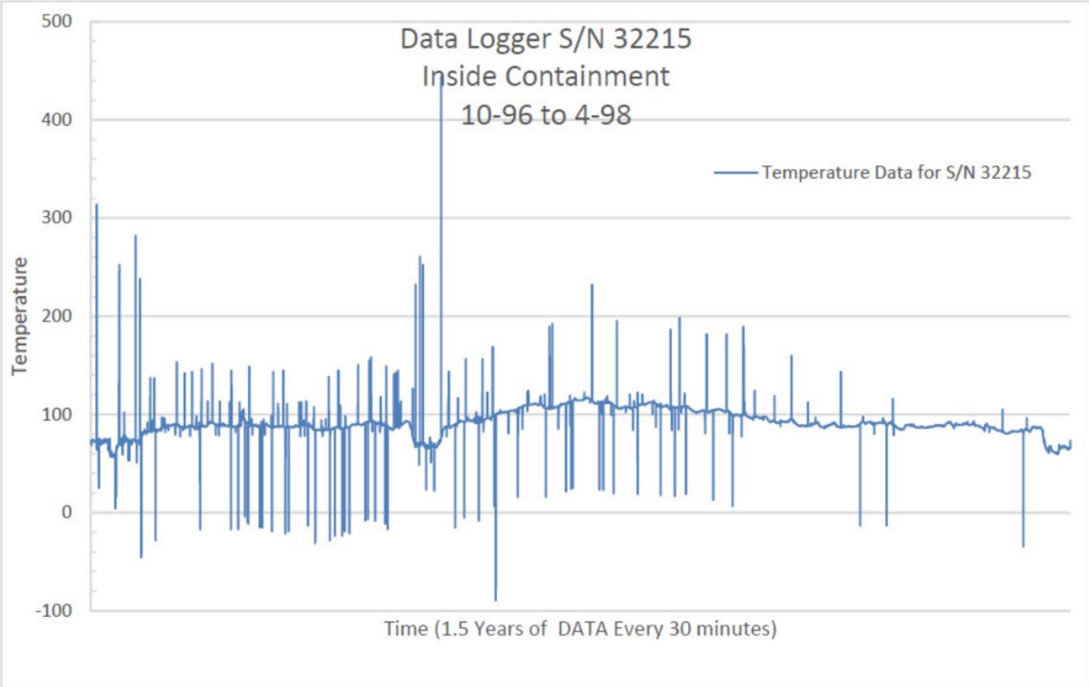
若 Temperature Monitoring 採用數位式溫度監測，在一個燃料周

期時間(1.5 年)，每分鐘紀錄一筆的話，每一個溫度記錄器會有高達788,400 筆(365x1.5x24x60)的資料量，分析數據而言對於是非常龐大的，由於核電廠內環境溫度的變化是緩慢的變化的，所以溫度記錄時採用奈奎斯特取樣定理，可以大幅減少處理的資料量，建議的溫度取樣頻率與資料量如下表所列:

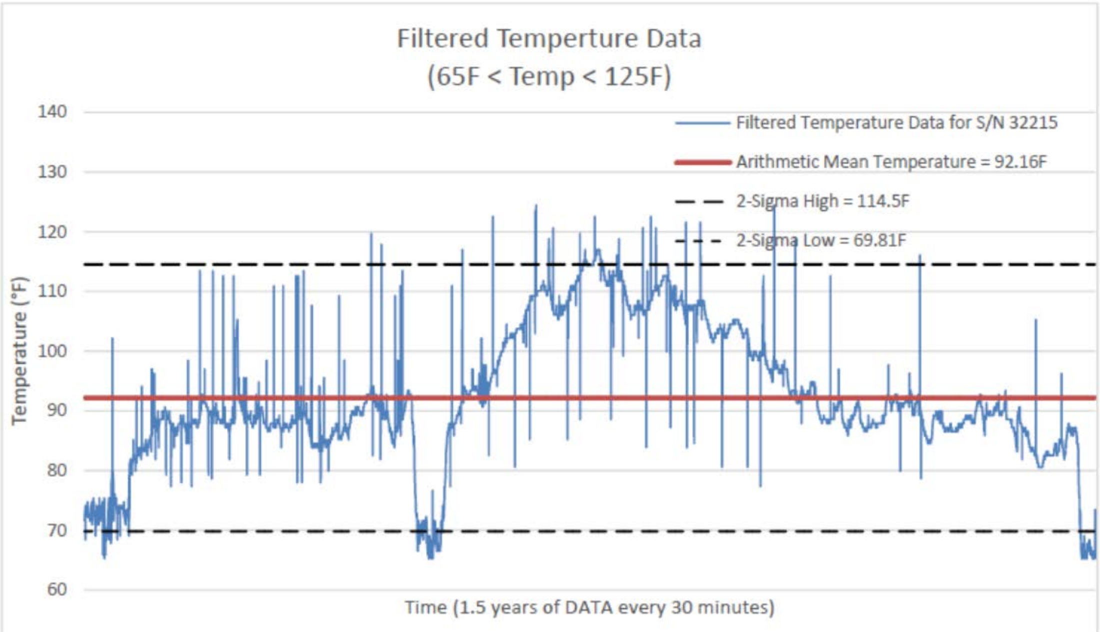
| Sampling Rate vs. Data Logger Memory Requirements | | | | | | |
|---|---|---|---|---|---|---|
| Sample Rate | | Proposed Temperature Monitoring Duration (yrs) | | | | |
| Readings (per day) | Readings (per hr) | 1 | 1.5 | 2 | 3 | 4 |
| | | Data Logger Memory Requirements (# of Readings) | | | | |
| 4 | 0.17 | 1460 | 2190 | 2920 | 4380 | 5840 |
| 8 | 0.33 | 2920 | 4380 | 5840 | 8760 | 11680 |
| 12 | 0.5 | 4380 | 6570 | 8760 | 13140 | 17520 |
| 24 | 1 | 8760 | 13140 | 17520 | 26280 | 35040 |
| 48 | 2 | 17520 | 26280 | 35040 | 52560 | 70080 |

以上表每小時記錄兩筆的方式，在一個大修週期，僅有 26280 筆溫度數據量，與低於每分鐘紀錄一筆的 788,400 筆，對於後續資料處理而言，可減少大幅的工作。

收集到溫度數據後要先分析其資料的有效性，將可疑的或無效的數據排除，排除方式係參考簡事發生時間點時，電廠是否有異常現象，例如功率變化、通風系統異常等，另外再看附近是否有其它的溫度記錄器當時的溫度值是否正常，若無異常現象且附近的溫度記錄器當時的溫度值是正常，可將該異常溫度排除，以下是圖一、二為案例說明。




圖一、一個大修週期的原始溫度數據




圖二、排除可疑的或無效的數據後的溫度數據

溫度數據之應用，本課程採用統計學的方法，可採用 Maximum and Minimum Temperatures During Period、Arithmetic Mean Temperature

During Period 或 Standard Deviation of Mean Temperature，另外還有其他方法可以使用 Temperature / Frequency Histogram、% of Time Above a Temperature or Temperature Range、Arrhenius Equivalent Temperature、Fast Fourier Transform (FFT)等，以提供組件壽命重新評估時之熱老化溫度。

我們在課程中請教講師兩個問題，首先詢問若組件在安裝後第五年才開始執行溫度監測，是否可以第五年監測之後的溫度數據代表前五年的環境溫度，講師答覆需要評估溫度監測前後這段時間內，電廠並未有任何功率變化、設計改善案、或功率提昇等，亦要額外確認組件所處環境沒有任何局部 hot spot 點在附近。第二問題係問組件壽命重新評估時之熱老化溫度還要加上多餘裕(Margin)溫度，本課程建議之餘裕溫度為 2～6℉是否會太低，講師則說以組件壽命重新評估的 10℃(18℉)法則，熱老化溫度每增加 10℃，組件壽命減少一半，因此在執行組件壽命重新評估時，是希望能夠延長組件壽命，若餘裕溫度很大的話，組件可以延長的壽命會很短，相對而言就是增加更換頻率，亦會增加設備的成本。上述兩個問題，可以於本所執行核電廠整廠時限老化分析作業時，提供遵循的依據。

訓練課程中提及一些相關的歷史運轉經驗，可以研讀 NRC Information Notice 86-49, Age/Environment Induced Electrical Cable Failures, NRC Information Notice 87-65, Plant Operation Beyond Analyzed Conditions 與 NRC Information Notice 89-30, High Temperature Environments at Nuclear Power Plants。講師建議可研讀相關規範如:

(一)RG 1.211：Qualification of Safety-Related Cables and Field Splices for Nuclear Power Plants.

(二)RG 1.218：Condition Monitoring Techniques for Electric Cables Used in Nuclear Power Plants

(三)NUREG/CR-6704, Vol. 2：Assessment of Environmental Qualification Practices and Condition Monitoring Techniques for Low Voltage Cables

(四)NUREG/CR-7000：Essential Elements of an Electric Cable Condition Monitoring Program

(五)SAND96-0344：Aging Management Guideline for Commercial Nuclear Power Plants – Electrical Cable and Terminations

美國工業界相關指引，EPRI 與 IEEE 相關技術報告

(一)EPRI 1021067：EQ Reference Manual (formerly 100516)

(二)EPRI 109619：Guideline for the Management of Adverse Localized Equipment Environments

(三)EPRI 104873：Methodologies and Processes to Optimize EQ Replacement Intervals

(四)EPRI NP-7399：Guide for Monitoring Equipment Environments during Nuclear Plant Operation

(五)EPRI 1006534：Infrared Thermography Guide (Revision 3)

(六)IEEE Standard 1205：IEEE Guide for Assessing, Monitoring, and Mitigating Aging Effects on Class 1E Equipment Used in Nuclear Power Generating Stations.

圖三、與講師 Ron Wise 和 Rick Weinacht 合照

「第二十七屆設備驗證技術研討會」研討內容包含 EQ Perspective at the 45th Anniversary of IEEE 323(IEEE 323 回顧)、Implementation of 10 CFR 50.69 at Southern Nuclear Operating Company(10 CFR 50.69 檢驗，記錄，報告，通知之應用，成果說明、IEEE Conformity Assessment for Nuclear Devices(IEEE 合格評估)、Namco Magnetic Proximity Switch for Valve Position Indication(新一代 switch 介紹，新技術 SNAP-LOCK Technology)、Leveraging the Lessons Learned from AP1000 Qualification Testing(ASCO 新的 NT 系列電磁閥介紹)、Essentials of EMC for Nuclear Plant Equipment Qualification(新的 EPRI TR-102323 R4 討論)、MSIV Room EQ Analysis of APR1400 Using RELAP5-ME and GOTHIC(新的軟體 RELAP5-ME 與 GOTHIC 對 MSIV Room 比較與分析)等。

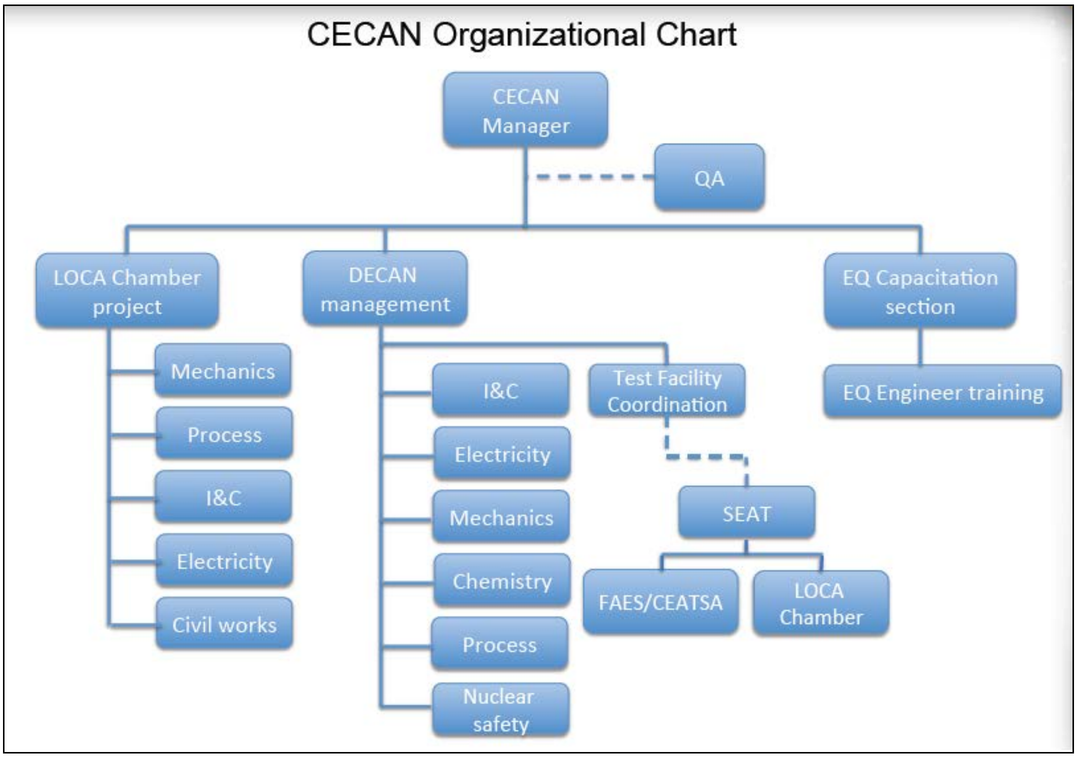
由於電纜檢測是電廠老化管理關注的重點之一，會議中詢問演講者對於防火被覆電纜是否可以檢測，演講者表示電纜老化檢測僅針對

遭受熱與輻射的電纜，針對防火被覆電纜則未曾檢測過。

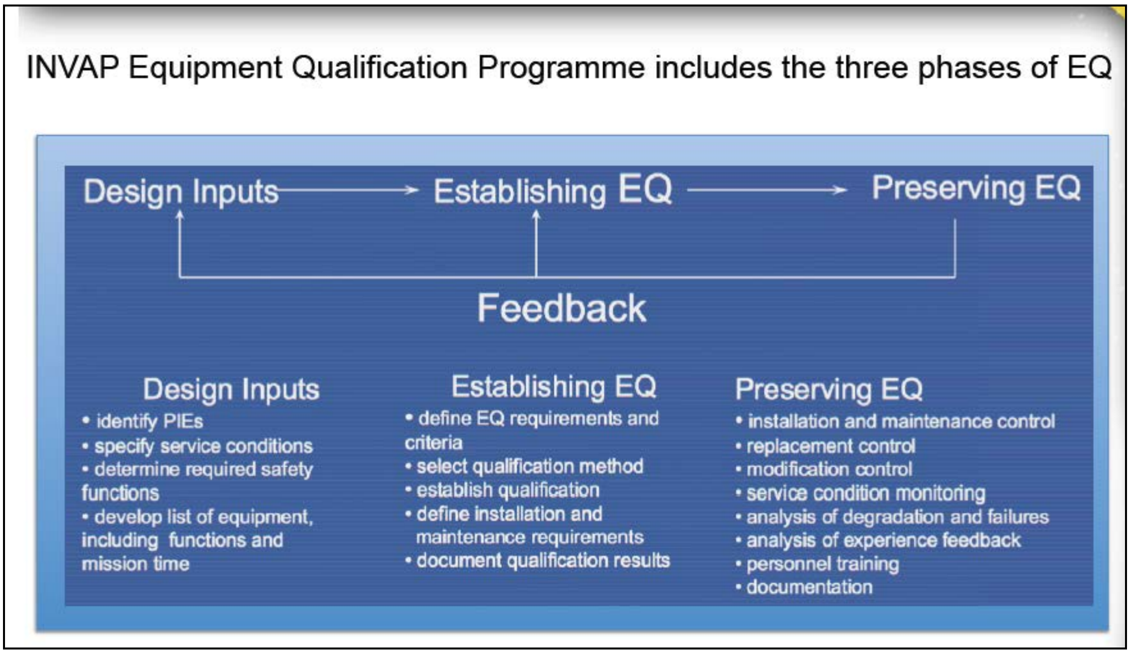
本次研討會有介紹核能級產品－Namco Magnetic Proximity Switch 型號 EA 120。Namco Limit Switch 國內核電廠所使用的型號為 EA 170、EA 180 與 EA 740 系列為大宗，其中 EA 170 不可用於乾井內等嚴酷環境，EA 180 雖然可用於嚴酷環境，但是 EA 180 次組件 Elastomeric 與 Thermoset Plastic Contact Carrier&Contact Block 均須定期更換，EA 740 亦可用於嚴酷環境，但是其壽命不到十年(在 57℃使用溫度下)。這次 Namco 的 EA 120 產品可在在 56.1℃使用溫度下具有 60 年壽命，LOCA 測試時最高溫度可耐 480℉與 MSLB 測試時最高溫度可耐 540℉，均超過一般核能級產品之驗證溫度；其耐輻射總劑量可達 363 Mrads (Gamma)，遠超過一般核能級產品的 200 Mrads。Namco 導入 SNAP-LOCK® technology 專利，當 Switch 在開關時不易受到振動。

本次研討會亦有 INVAP 公司 EQ-Center 專案經理，介紹阿根廷在環境驗證方面的經驗與現況。INVAP 公司成立於 1976 年，係由阿根廷原子能委員會的研究實驗部門拆分出來的私人公司。該公司在核能、航太、化工、醫藥、石油方面，提供整合、設計、設備與建廠等方面之服務，服務範圍遍及北美、歐洲、亞太、拉丁美洲、中東與非洲等區域。在核電方面，INVAP 公司有從事核電廠之設計與建造，從 1982 起至 1997 年間，INVAP 公司藉由參與設計與建造六座核電廠的經驗，INVAP 公司逐步建置其耐震、溫度與濕度測試驗證。由過去之經驗，2003 年 INVAP 公司發展出第一個核電廠環境驗證方案，這個方案係符合 IEEE Class 1E 標準，並在應用於澳洲雪梨的 OPAL 電廠設計與建造，由超過 110 個的組件(大部分位於溫和環境)藉由 Type test 通過環境驗證測試。由過去之經驗，INVAP 公司於 2014 年初，

決定成立其環境驗證中心，以幫助阿根廷政府國家核能計畫，於未來十年內建造三座核電廠，並且國家核能計畫至少要能有 70%可以自行整合。INVAP 公司與 ARSAT 電信公司合資成立 CEATSA(Centro de Ensayos de Alta Tecnología Sociedad Anónima)環境測試公司，提供 INVAP 公司在環境驗證之測試能量，可提供振動測試、環境測試、EMC 測試，目前正在建置 LOCA 測試設備，預計於 2016 年完工。




圖四、INVAP 公司環境驗證中心組織圖




圖五、INVAP 公司環境驗證流程


圖六、Bill Horin 介紹 EQ 的歷史


圖七、Alberto Busto 介紹阿根廷 EQ 的經驗與狀態


圖八、李耀民與 NRC 官員 Teh-Chiun Su 合照


圖九、楊智堯與 NRC 官員 Teh-Chiun Su 合照

# 三、 心得

在環境溫度監測方面，如果安裝溫度監測以前，該環境未有任何 Design change/Power change 等，可以合理假設該環境未曾發生環境變化，引用溫度監測後之溫度數據，但要有合理的評估。關於組件壽命重新評估時之熱老化溫度需加上多少餘裕(Margin)溫度，若是提高 margin 例如到 10℃，組件壽命會縮短一半，更換周期亦會縮短，對業界而言，會增加成本。亦可以參考 IEEE 323 建議之 margin 值。

針對 INVAP 公司與本所檢證中心的技術能量進行比較，兩者均有環境驗證測試設備，但是本中心設備中最大尺寸規模的環境驗證設備可以容納馬達控制中心，INVAP 公司環境驗證測試設備並不能容納；關於耐震驗證實驗室，INVAP 公司僅有振動平台，本中心有耐震平台但是沒有振動平台；本中心與 INVAP 公司均有 EMC 實驗設備；LOCA 測試設備 INVAP 公司正在建置中，本所 LOCA 測試設備 82 年成立至今，已有核能級電纜國產化驗證、核三廠定位器事故驗證、與核一廠 Class 1E 低壓電纜驗證等實績。兩者比較，本檢證中心的測試能量比 INVAP 公司多，但是設備較老舊，未來若相關測試規範有要達到更嚴苛的測試條件，本檢證中心的設備可能會無法達到，目前僅有耐震驗證實驗室正在規劃更新震動平台，其它的測試設備仍需要經費進行更新與維護。

# 四、 建議事項

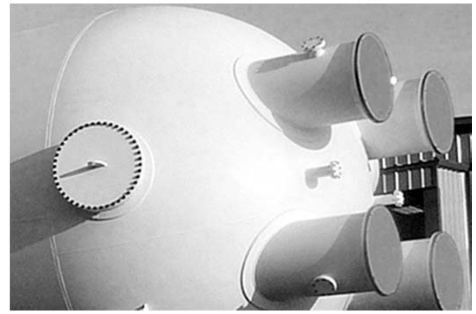
(一)本檢證中心的測試設備建置已有很長的時間，本中心人員花費相當的努力維護測試設備，以提供本檢證中心的技術服務案的測試作業。建議本檢證中心未來仍需持續關注國外驗證實驗室的測試能量，亦要規劃更新相關的測試設備，讓檢證中心的測試能量能夠持續成長，以提供更好的技術服務。

(二)美國核電廠不需送壽命重估結果給 USNRC 核准，但是 USNRC 之視察員於視察期間會去檢視壽命重估的文件。今天研討會有遇到 USNRC 之官員(The-Chiun Su)(他是台灣人，在核二廠服務過一段時間，才到美國念書，並於畢業後到美國電廠做過後才到 NRC)，他目前在 NRC regin2 部門，管理興建中、營運中之電廠，他在視察美國核電廠，也發現美國核電廠壽命評估文件寫得不很清楚。

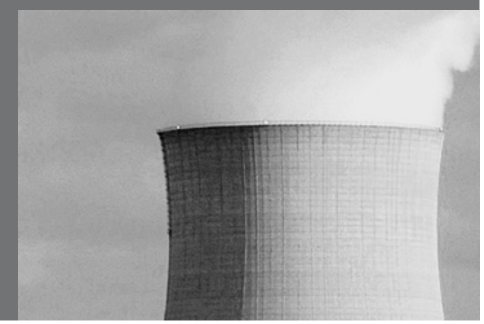
(三)環境設備的驗證與壽命評估一直是國內核電廠的重要工作，因此未來應持續參與嚴酷環境之設備驗證相關技術交流的研討會，多與美國業界人員交流。

# 附件一

# Temperature Monitoring訓練資料



# Temperature Monitoring for EQ Engineers
# Advanced EQ Training



*Rick Weinacht*

*Ron Wise*

*Nov 2-3, 2015*

# Introductions

Introductions and Student Expectations

Instructors:  Rick Weinacht & Ron Wise
Auditor/Advisor: Dick Butwin

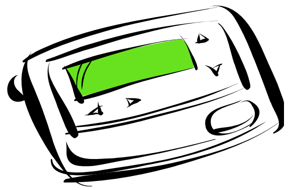
Student participation is highly encouraged

Questions and use of a “parking lot”

Please feel free to ask questions at any time

# Ground Rules

**Phone calls**
**only at breaks**



**Phones & Pagers**
**on SILENT MODE**

# Workshop Format

- Lots of Class Time for Exercises
- Training & Benchmarking Workshop
- We will develop a survey as we go along through the workshop
- The completed survey questionnaire will be the output of the workshop
- Curtiss-Wright will distribute the survey, collect the answers and issue a report following the Workshop to enhance the benchmarking experience
- Attendees will receive a final survey report

# Topics and Agenda

## Day 1

- Historical and Regulatory Information Related to Temperature Monitoring
- Class Exercise #1:  Case Study: TM Issue Raised During Diablo Canyon Construction Permit Recapture
- Purpose & Objectives for Temperature Monitoring
- Planning
- Selection of Monitors
- Class Exercise #2 :  Selection of Temperature Monitors

# Topics and Agenda

Day 1

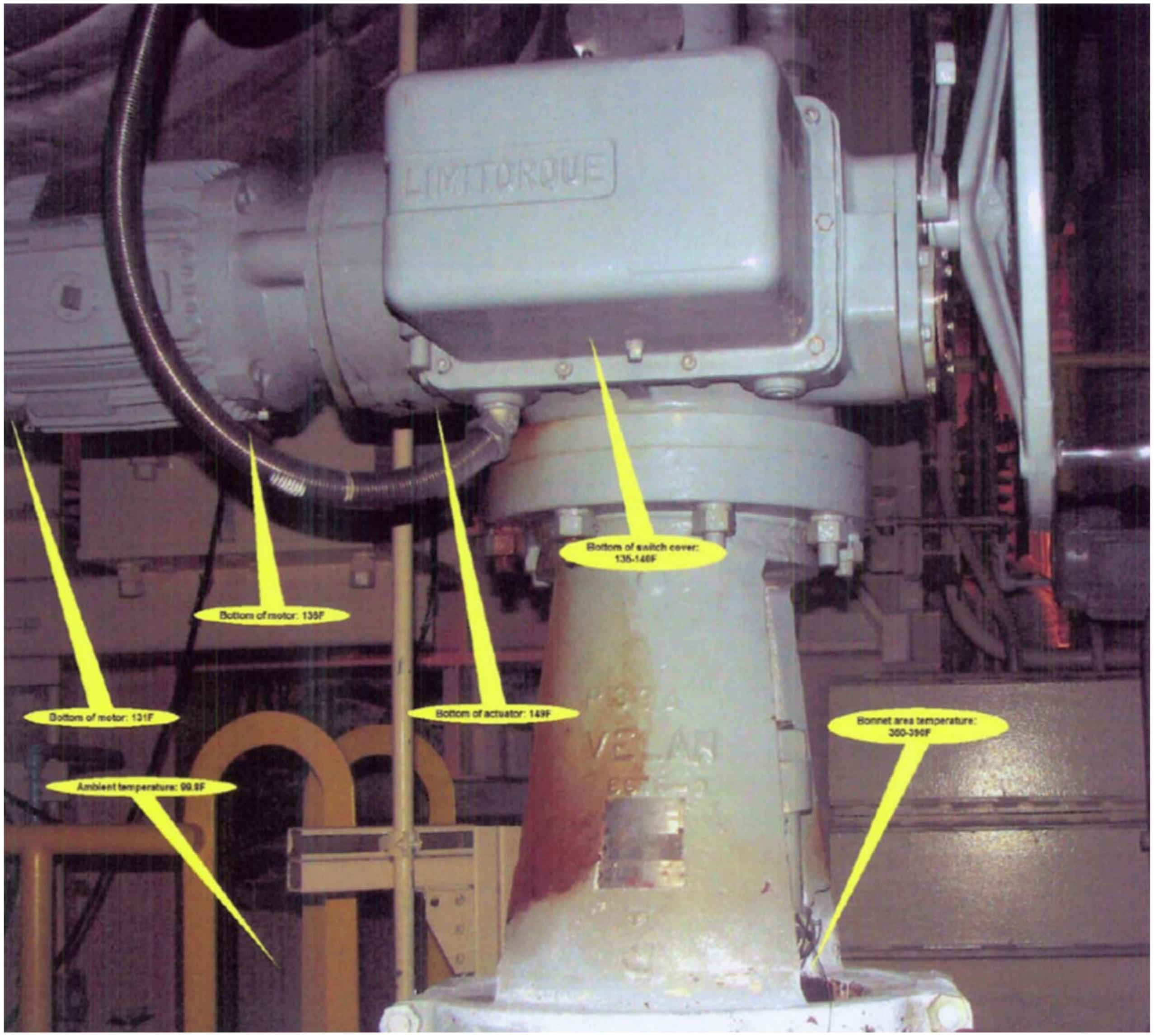
- Installation Considerations
- Analyzing the Results
- Class Exercise # 3:  Analysis of Temperature Monitoring Data

# Topics and Agenda

Day 2

- Documenting the Results
- Application of the Results
- Class Exercise # 4: Selection of Normal Temperature
- Class Exercise # 5:  Reanalyzing the Thermal Life
- Considerations for Establishing Frequency of TM Activities
- Survey Questionnaire Finalization
- Closing Remarks and Take-Aways

# Historical and Regulatory Information & Experiences



# Historical and Regulatory Information & Experiences

Topics

- What is Temperature Monitoring (TM)?
- Typical Uses for TM
- Regulatory Requirements and Expectations
- Some Relevant Historical OE
- Regulatory Support of Monitoring Operating Environments
- Other Relevant Regulatory Guidance
- Industry Guidance
- Benefits of a Temperature Monitoring Program
- Significance of Adverse Localized Environments

Class Exercise #1: Case Study: TM Issue Raised During Diablo Canyon Construction Permit Recapture

# What is Temperature Monitoring (TM)?

- The most common form of environmental monitoring used by EQ programs
- Can consist of one or more of the following:
  - One-Time or Discrete monitoring
  - Periodic or Repetitive monitoring
  - Continuous monitoring
- Can apply to:
  - Plant Areas
  - Equipment
  - Cables & Commodity Items

# Typical Uses

- To validate or verify current service conditions remain within analyzed limits
- To quantify degree of conservatism in existing normal service temperature conditions
- To define actual operating temperature conditions
- To identified localized hot spots or adverse temperature conditions
- As part of a feedback mechanism to adjust Qualified Life of EQ equipment

# Regulatory Requirements and Expectations

10CFR50 Appendix A, Criterion IV (1960s in various forms):

*Criterion 4—Environmental and dynamic effects design bases*. Structures, systems, and components important to safety shall be designed to accommodate the effects of and to be compatible with the environmental conditions associated with normal operation, maintenance, testing, and postulated accidents, including loss-of-coolant accidents.

# Regulatory Requirements and Expectations

10CFR50.49 (d)(3) [1983]:

The qualification file shall included information on:

The environmental conditions, including *temperature*, pressure, humidity, radiation, chemicals, and submergence *at the location where the equipment must perform* as specified in accordance with paragraphs (d) (1) and (2) of this section.

# Regulatory Requirements and Expectations

The regulatory requirement to establish qualification *at the location where the equipment must perform* can impose limitations on the use of general area or bulk average room temperatures since this wouldn't account for:

- Thermal Stratification
- Self Heating Effects
- Process Fluid Effects
- Panel/Cabinet/Enclosure temperature rise
- Local Hot Spots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# Regulatory Requirements and Expectations

10CFR50.49 (e) The EQ Program must include and be based on:

(5): Aging

Equipment qualified by test must be preconditioned by natural or artificial (accelerated) aging to its end of-installed life condition.

Consideration must be given to all significant types of degradation which can have an effect on the functional capability of the equipment.

The equipment must be replaced or refurbished at the end of this designated life unless ongoing qualification demonstrates that the item has additional life.

# Regulatory Requirements and Expectations

RG 1.89, Revision 1 [1984] C.5 – Section 6.3.3, "Aging" of IEEE 323-1974 should be supplemented with:

b. The expected *operating temperature of the equipment* under service conditions should be accounted for in thermal aging.

The Arrhenius methodology is considered an acceptable method of addressing accelerated thermal aging within the limitation of state-of-the-art technology.

Other aging methods will be evaluated on a case-by-case basis.

# Regulatory Requirements and Expectations

RG 1.89 C.5

*d. Periodic surveillance and testing programs* are acceptable to account for uncertainties regarding age related degradation that could affect the functional capability of equipment.

Results of such programs *will be acceptable as ongoing qualification to modify designated life (or qualified life)* of equipment and should be incorporated into the maintenance and refurbishment/ replacement schedules.

# Some Relevant Historical Operating Experience (OE)

- As early as 1982, equipment failures and issues related to localized temperatures occurred
- The NRC issued generic correspondence for some of these events:
  - NRC Information Notice 86-49: Age/Environment Induced Electrical Cable Failures
  - NRC Information Notice 87-65: Plant Operation Beyond Analyzed Conditions
- Eventually, in 1988, NRC Issued TI 2515/98, *INFORMATION OF HIGH TEMPERATURE INSIDE CONTAINMENT/DRYWELL IN PWR AND BWR PLANTS*

# Some Relevant Historical Operating Experience (OE)

Key Points from NRC IN 86-49, Age/Environment Induced Electrical Cable Failures:

- Alerted industry to age / environment induced failure of cables at San Onofre Unit 1
- Offsite power was lost when a transformer was tripped by its differential relays because of a fault in the cable to the Class 1E 4160V bus
- Cable failed between phases with evidence of insulation degradation and arcing
- Cause attributed to temperature induced accelerated aging and degradation of cable insulation

# Some Relevant Historical Operating Experience (OE)

## Key Points from NRC IN 86-49:

- The heat source was a bare (uninsulated) high temperature (400°F) feedwater line and pipe flange in the immediate vicinity of the cable
- The thermal insulation had been removed from the pipe during a previous repair of a gasket leak and was not replaced
- Event formally investigated by NRC and described in NUREG-1190

# Some Relevant Historical Operating Experience (OE)

Key Points from NRC IN 86-49:

- Staff concerns identified as:
  - Possible weakness in the surveillance and maintenance of station electrical cables
  - An important facet of the periodic maintenance and testing program for cable circuits is the walkdown inspection to identify actual or potential environmental conditions (heat, water, chemicals, etc.) in the immediate vicinity of cables that could adversely affect the cable conditions

# Some Relevant Historical Operating Experience (OE)

Key Points from NRC IN 87-65, Plant Operation Beyond Analyzed Conditions:

- ANO-1 operated with containment temperatures ranging from 103°F to 165°F
- One local hot spot of 183°F
- Several DBA analysis assumed an initial containment temperature of 110°F
- EQ Equipment Qualified for normal temperatures of 120°F
- Conditions existed since plant startup in 1974

# Some Relevant Historical Operating Experience (OE)

## Key Points from NRC IN 87-65:

- **Staff concerns included EQ and Containment Integrity:**
  - Plant operated beyond its analyzed basis with regard to post-accident (LOCA) containment performance because initial conditions assumed in the analysis were exceeded
  - Higher temperatures implies accelerated aging of equipment required for post-accident safe shutdown in accordance with 10CFR50.49
  - Higher temperatures may cause deterioration of the concrete structure.

# Some Relevant Historical Operating Experience (OE)

- TI 2515/98 Documents accelerated aging to cables and equipment at LaSalle and Dresden
- Several Plants were inspected against this TI
- Objective of TI was to determine if high containment or drywell temperatures were a plant specific problem or generic to all PWRs and BWRs
- Information Notice 89-30, *High Temperature Environments at Nuclear Power Plants*, essentially summarizes results of these inspections

# Some Relevant Historical Operating Experience (OE)

## Key Points from NRC IN 89-30 (Including S1):

- Alerted Industry to Potential Problems from high temperature environments in areas that contain safety related equipment or cables
- Points out examples of BWRs and PWRs with elevated drywell or containment temperatures
- Elevated temperatures identified as being responsible for degradation of safety-related equipment and cables
- Elevated temperatures identified as being higher than used in containment safety analysis and EQ

# Some Relevant Historical Operating Experience (OE)

## Key Points from NRC IN 89-30 (Including S1):

- Preliminary Findings from the TI showed that:
  - BWRs (especially Mark I and Mark II containments), routinely operate very close to their EQ temperature limit
  - In BWR drywells, there may be substantial temperature gradient (i.e. 100°F or more) that may or may not be detected depending on location of instrumentation and circulation of the drywell air.
  - The BWR drywell head region seems most susceptible to high temperatures.
  - Some PWRs experience high containment temperatures but licensees failed to recognize the safety significance and take corrective actions.

# Some Relevant Historical Operating Experience (OE)

## Key Points from NRC IN 89-30 (Including S1):

- Supplement 1 to IN 89-30 covered additional examples of:
  - Potential equipment failures or spurious ESFAS signals resulting from elevated temperature conditions in cabinets and panels containing electrical equipment
  - Consequential failure of EDG electrical components following a modification that removed insulation from the Diesel exhaust headers.

# Regulatory Support of Monitoring Operating Environments

ML021790551, Technical Assessment of Generic Safety Issue 168, 'Environmental Qualification of Low-Voltage Instrumentation & Control (I&C) Cables, Section 6.1.6:

Issue 6. *Can condition-monitoring techniques be used to predict LOCA survivability?*

> As stated earlier, although a single reliable condition-monitoring technique does not exist, walkdowns to look for any visible signs of anomalies attributable to cable aging, *coupled with the monitoring of operating environments*, have proven to be effective and useful.

# Regulatory Support of Monitoring Operating Environments

- NRC Regulatory Issue Summary: RIS 2003-09, Environmental Qualification of Low-Voltage Instrumentation and Control Cables
  - Addressed the technical assessment of GSI-168
  - Acknowledges that using the difference between actual operating environment and the original qualification environment to extend the thermal life using Arrhenius methodology has been found acceptable by the staff.

# Other Relevant Regulatory Documents

- RG 1.211: Qualification of Safety-Related Cables and Field Splices for Nuclear Power Plants
- RG 1.218: Condition Monitoring Techniques for Electric Cables Used in Nuclear Power Plants
- NUREG/CR-6704, Vol. 2: Assessment of Environmental Qualification Practices and Condition Monitoring Techniques for Low Voltage Cables
- NUREG/CR-7000: Essential Elements of an Electric Cable Condition Monitoring Program
- SAND96-0344: Aging Management Guideline for Commercial Nuclear Power Plants – Electrical Cable and Terminations

# Industry Guidance

## EPRI Documents:

- 1021067: EQ Reference Manual (formerly 100516) 
- 109619: Guideline for the Management of Adverse Localized Equipment Environments
- 104873: Methodologies and Processes to Optimize EQ Replacement Intervals
- NP-7399: Guide for Monitoring Equipment Environments During Nuclear Plant Operation
- 1006534: Infrared Thermography Guide (Revision 3)

## Industry Guidance

# IEEE Documents:

- IEEE Standard 1205:  IEEE Guide for Assessing, Monitoring, and Mitigating Aging Effects on Class 1E Equipment Used in Nuclear Power Generating Stations

# Benefits of a Temperature Monitoring Program

- Provides evidence that plant conditions remain within design / analyzed limits
- Quantifies thermal environments at discrete locations and for bulk areas
- Detects changes in environments over time due to:
  - Design Changes
  - Changes in HVAC Performance
  - Changes in Heat Loads or UHS Temperature
  - Deterioration of Thermal Insulation
  - Seasonal Variations
  - Changes in Plant Operational Conditions

# Benefits of a Temperature Monitoring Program

- Produces information that supports evaluation of maintenance, refurbishment and replacement frequencies
- Directly supports the effectiveness of the aging management elements of the EQ Program
- Reduced maintenance costs by extending the Qualified Life of Equipment

# Significance of Adverse Localized Environments

- For EQ equipment, they may cause degradation of equipment that:
  - May not result in failure during normal operation, but
  - May render the equipment incapable of functioning properly during or after an accident

[REF: EPRI 109619]

# Temperature Monitoring

Time for Exercise #1

Case Study

Temperature Monitoring Issue Raised During

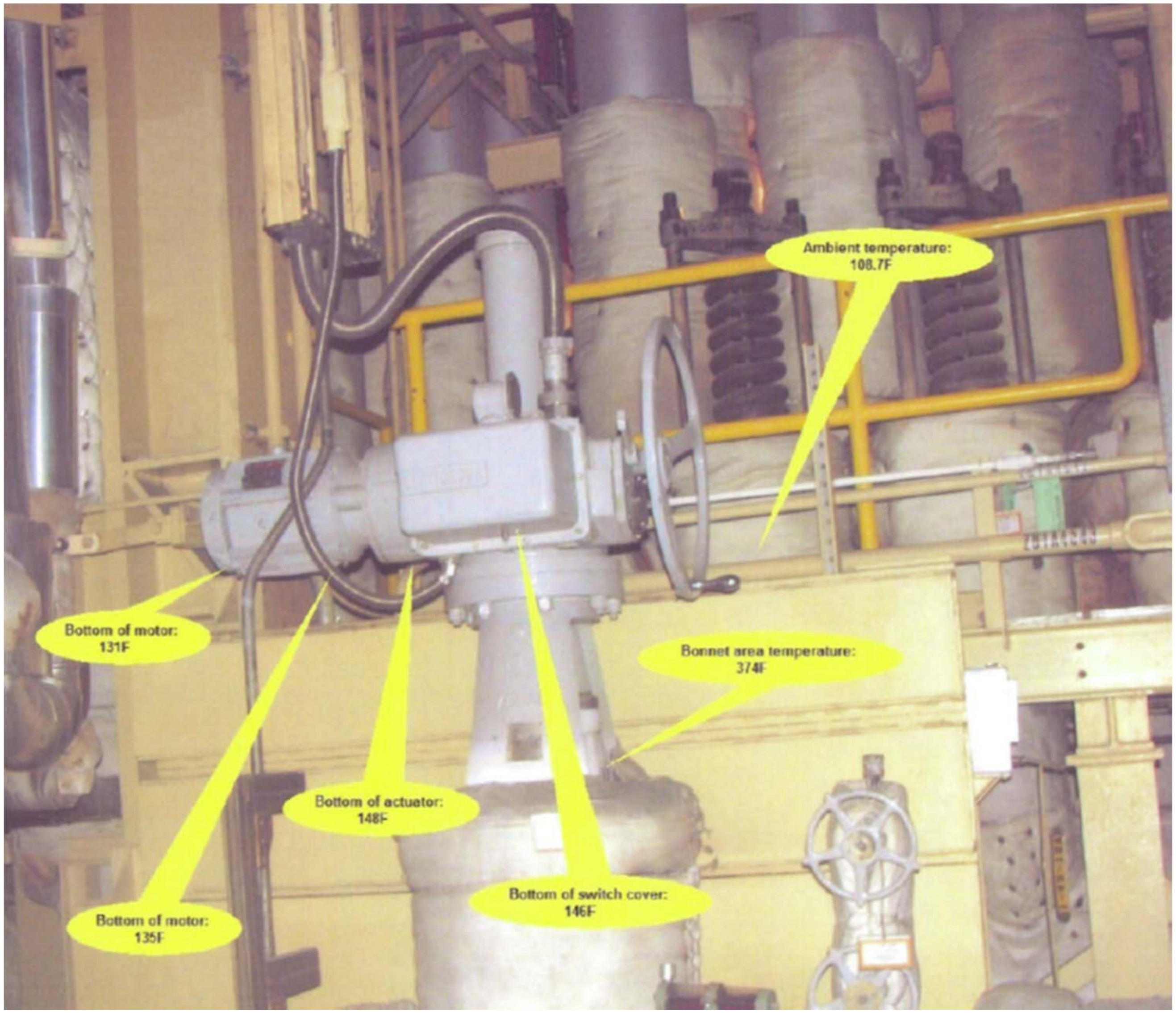
Construction Period Recapture

For Diablo Canyon NPP

(See Handout / Flashdrive)

# Purpose and Objectives for Temperature Monitoring



# Purpose and Objectives for Temperature Monitoring

Temperature Monitoring (TM) can have various objectives

- Most common reasons for performing TM includes:
  - Verifying that actual operating temperatures are within design or analyzed limits
  - Validating that service temperatures used to establish the Qualified Life of EQ equipment is representative of the actual conditions at the equipment location
  - Supporting Reanalysis of TLAA in support of License Renewal
  - Extending QL or EQ driven maintenance activities
  - Addressing Age Related Degradation or Equipment Failures
  - Identifying local hot spots or quantifying thermal stratification

# Purpose and Objectives for Temperature Monitoring

Temperature Monitoring can have various objectives

- Other Activities that can be supported by TM includes:
  - Providing a technical basis to justify an EQ PM deferral request
  - Operability Determinations and Functionality Assessments
  - Providing inputs related to initial temperature conditions for safety analysis or engineering calculations

# Purpose and Objectives for Temperature Monitoring

## Identification of Hot Spots



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# Purpose and Objectives for Temperature Monitoring

## Identification of Hot Spots

- Hot Spots or Localized Adverse Temperature Conditions can result from:
  - Normal Plant Operation
  - Degraded or Non-Conforming Conditions
  - Poor Design, Construction, or Maintenance Practices
- Hot spot Conditions can be:
  - Representative of long term equipment service temperatures
  - The result of short term temperature excursions whose cumulative effects needs to be accounted for in establishing the Thermal Life of equipment

 

# Purpose and Objectives for Temperature Monitoring

## Identification of Hot Spots
## EPRI TR-109619 Examples

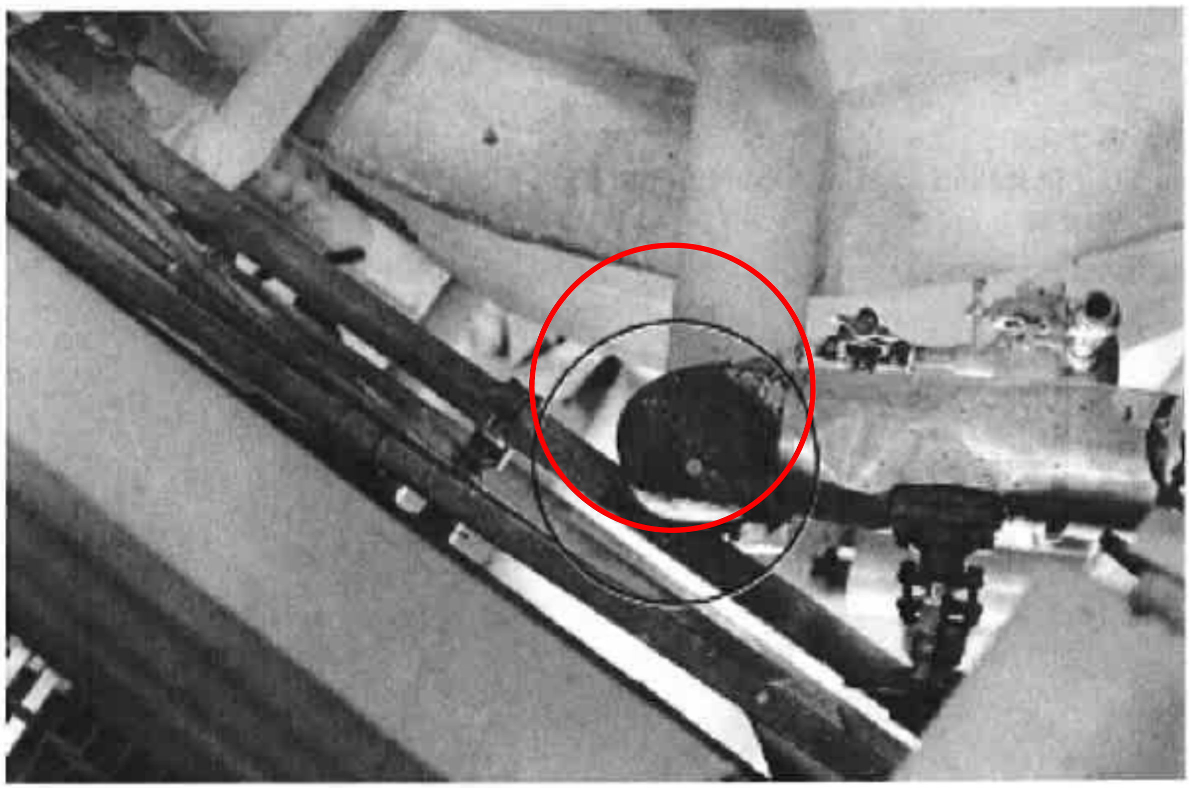

**Figure B-1**
**Pipe Insulation Partially Enveloping an Electrical Conduit**

# Purpose and Objectives for Temperature Monitoring

## Identification of Hot Spots
## EPRI TR-109619 Examples

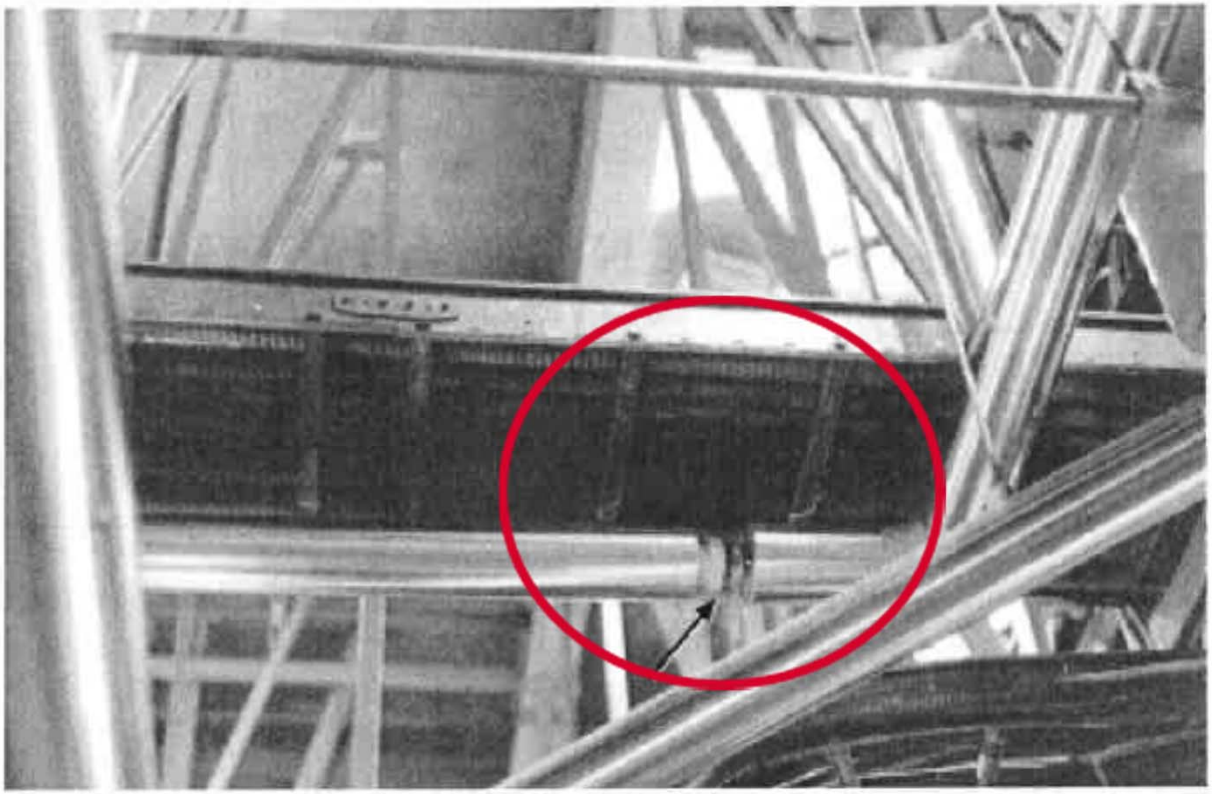

**Figure B-2**
**Cable Tray Installed near an Uninsulated Pipe Flange**

 

# Purpose and Objectives for Temperature Monitoring

## Identification of Hot Spots
## EPRI TR-109619 Examples

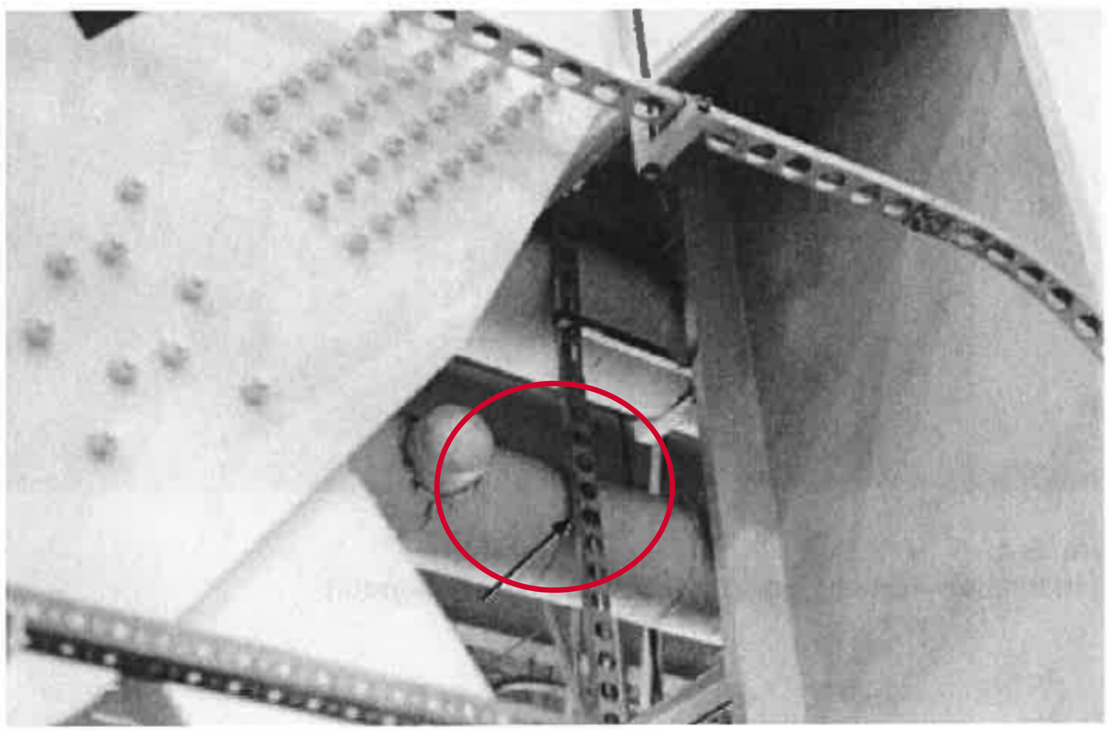

**Figure B-3**
**Cable Tray in Contact with Pipe Insulation**

 

# Purpose and Objectives for Temperature Monitoring

## Identification of Hot Spots
## EPRI TR-109619 Examples

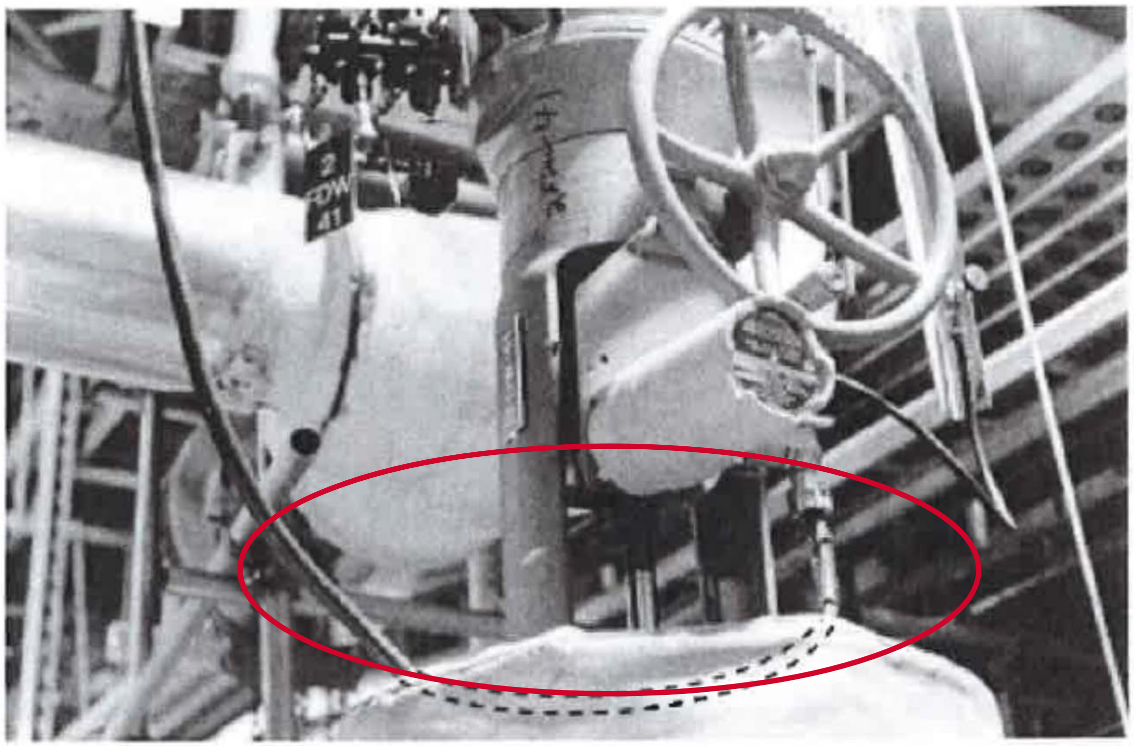

**Figure B-4**
**Cable Installed Underneath Thermal Insulation Surrounding a Hot Component**

 

# Purpose and Objectives for Temperature Monitoring

## Identification of Hot Spots
## EPRI TR-109619 Examples

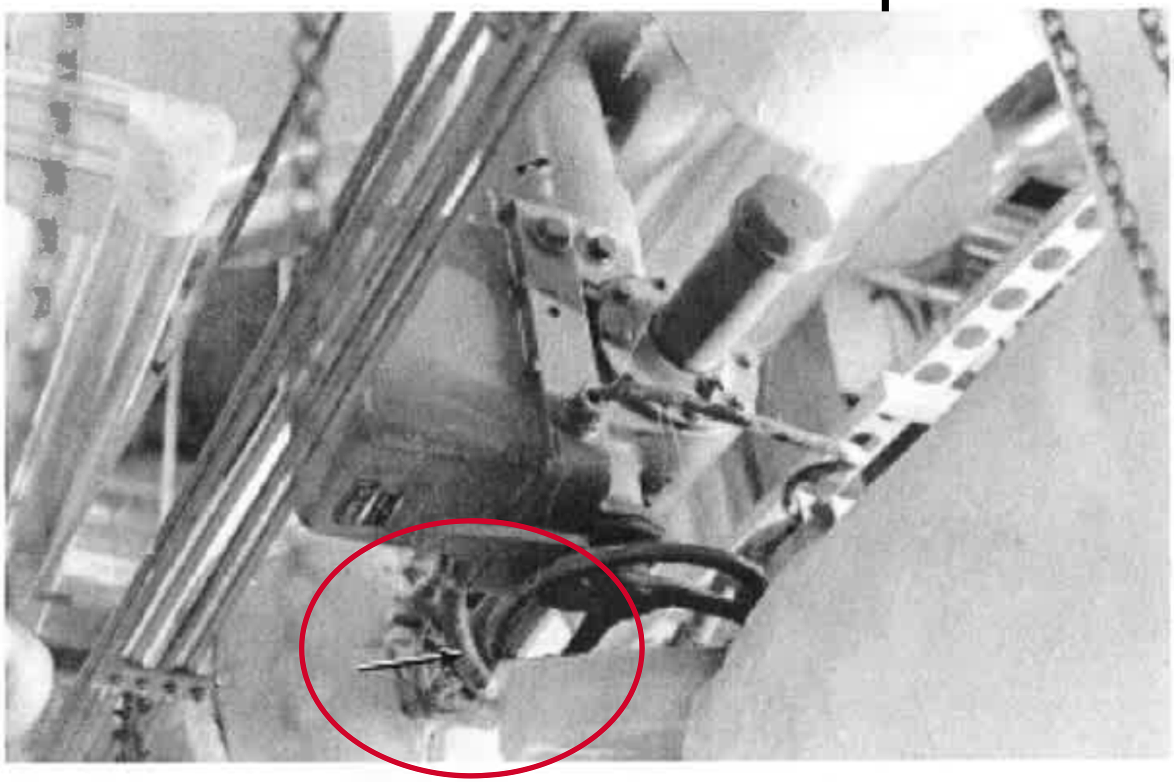

**Figure B-7**
**Cable Installed near a Hot Valve (Infrared Thermography indicated 150°F at cable surface.)**

 

# Identification of Hot Spots
# EPRI TR-109619 Examples

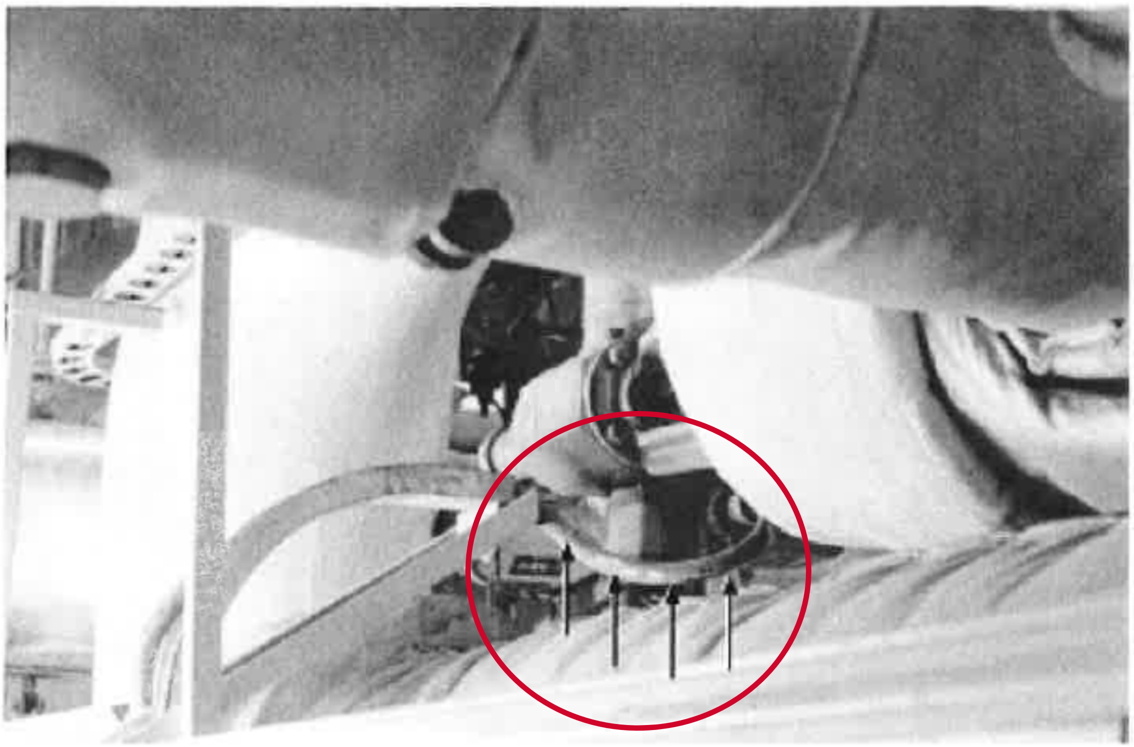

**Figure B-8**
**Opposite Side View of Installation in Figure B-7**

# Purpose and Objectives for Temperature Monitoring

## Identification of Hot Spots
## EPRI TR-109619 Examples

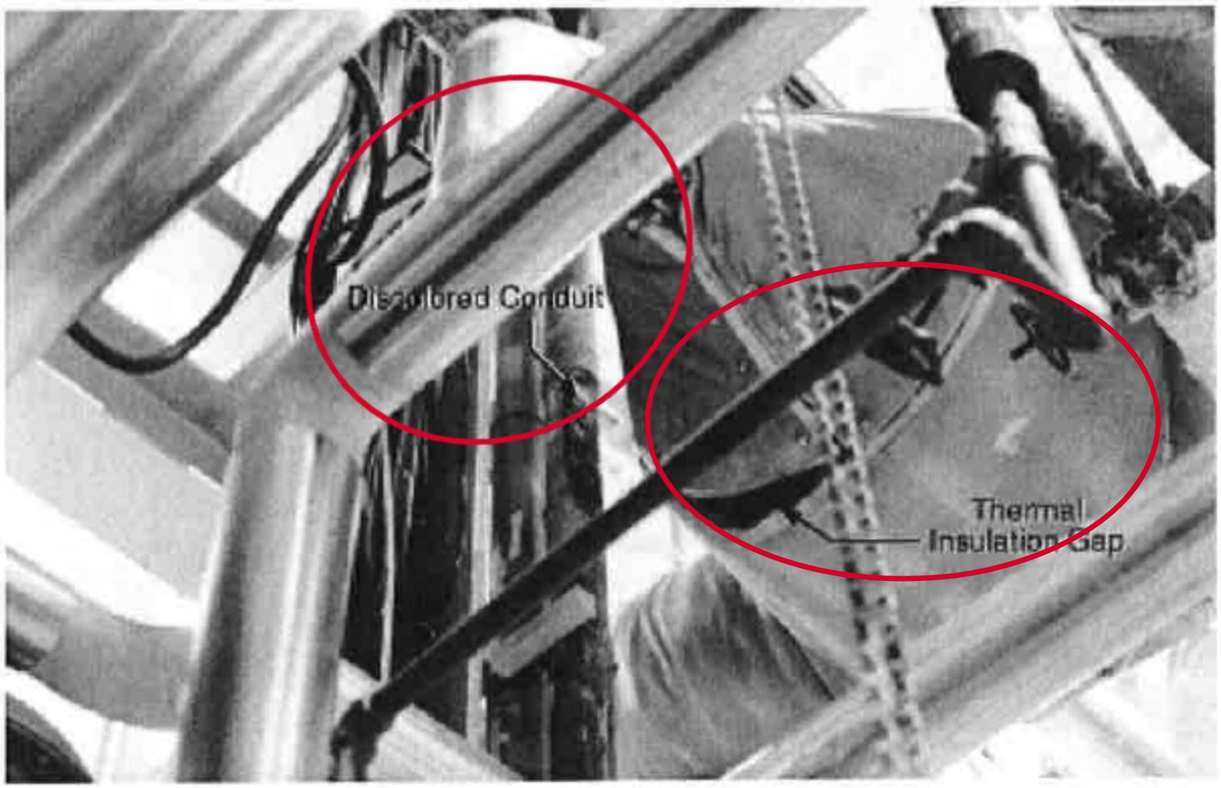


**Figure B-11**
**Scorched Conduit Located near a Valve with Improperly Installed Insulation**

# Purpose and Objectives for Temperature Monitoring

## Identification of Hot Spots

- Hot Spots from Normal Plant Operation include:
  - Thermal Stratification Effects
  - Process Fluid temperature rise
  - Cabinet / Panel temperature rise or Self Heating Effects
  - Infrequent Plant Operating Modes or Valve Lineups
  - Consequential effect of Design Changes
- Hot Spots from Degraded/Non-Conforming Conditions can include:
  - Degraded, Missing, or Improperly installed thermal insulation
  - Degraded HVAC performance or HVAC related failures
  - Mis-positioned HVAC dampers
  - Routing Cables in Close Proximity to High Energy Piping
  - Loose Electrical Connections

# Purpose and Objectives for Temperature Monitoring

## Identification of Hot Spots

- Traditionally Performed as part of the plant's response to Operating Experience
    - NRC IN 89-30, 86-49, 87-65, etc.
- Hot Spot Temperature Conditions can exist in areas where the bulk average ambient temperature is within Design or Tech Spec limits.
- Hot Spot Temperature Conditions can have impacts beyond Thermal Qualified Life:
    - Initial temperature conditions for Thermal Lag Analysis
    - Equipment temperature rise data can change

 

# Other Hot Spot Examples


Discharge from Limitorque Grease Relief Valve - Evidence of elevated main gearbox temperature

Evidence of Local Hot Spots Can Come From a Variety of Sources Besides TM

 

# Quantifying Margin in Temperatures Used to Establish QL

- Temperature Monitoring can be used to determine the degree of conservatism (or margin) between:
    - Temperature used to establish the Thermal Life, and
    - The actual equipment service temperature
- This can be based on Temperature Monitoring of:
    - General area (bulk) air temperatures,
    - Local ambient temperatures (close proximity to equipment)
    - External equipment service temperatures (contact)
    - Internal equipment temperatures
- Can be used as a Validation of Design

# Supporting Reanalysis of TLAA for License Renewal

- Other common objective of a TM Program is to support the Reanalysis of Time Limited Aging Analysis (TLAA) in support of License Renewal
- This is a specific application on using TM to quantify the conservatisms in the thermal aging analysis with the express purpose of extended the life beyond 40 years
- May be performed:
    - Prior to entering the period of extended operation
    - During the period of extended operation

 

# Extension of Qualified Life

- Reanalysis of an aging evaluation to extend the qualification of components under 10CFR50.49(e) is performed on a routine basis as part of an EQ Program
- Temperature Monitoring can have a significant role in the extension of Qualified Life due to:
  - The fact that Thermal Life is the frequently the limiting consideration for establishing the Qualified Life of EQ Equipment
  - The "exponential" sensitivity of the Arrhenius methodology to changes in service temperatures means that even relatively small reductions in temperatures can result in substantial extensions in EQ maintenance frequencies

# Planning

- Initial Step is typically to define the goals of the TM Program
- Planning Activities can include:
  - Review of Plant Equipment Arrangement Drawings
  - Review of Historical Plant Records
    - Containment air temperature monitoring
    - Operator logs
    - Corrective Action Program
    - Plant Responses to Applicable Operating Experience

 

# Planning

- Planning Activities can include (Continued):
  - Interview Plant Personnel who are knowledgeable of:
    - Historical operating temperature conditions
    - Changes in design or operation of HVAC system
    - Changes in thermal insulation or heat loads
  - Identifying Need for New or Revised Procedures
  - Plant Walkdowns
  - Identifying Permanently Installed monitors
    - Used to determine containment bulk average temperature
    - Used to monitor for leakage
    - Used to monitor temperature of “standby” equipment

# Planning

- Planning is fundamentally dependent on how the results of Temperature Monitoring will be used.
- Purpose dictates if TM:
  - Is Continuous, Periodic, One-Time, or a combination
  - Uses Permanently Installed, Temporary, Hand Held Monitors (or some combination)
  - Has QA Requirements (Procedural, Procurement, M&TE, etc.)
  - Will address specific plant areas or rooms
  - Will address specific plant equipment
- Establishes required resources (personnel & equipment)

# Planning

- Defining the Scope of a Temp Monitoring Program will depend on whether the effort will be:
    - Looking to verify if general Plant Areas / Rooms are being maintained within design limits
    - Looking for Local Hot Spot Conditions
    - To Quantify Conservatism in Normal Temperatures
    - Limited to EQ Equipment (e.g. Harsh Electrical)
    - Focused on Equipment with Short Qualified Life
    - Applied to Mechanical Equipment
    - Applied to Equipment in Mild Environments
    - Or Some Combination of the Above

# Safety Classification

## When is Temperature Monitoring Data Considered to be:

- Safety Related?
  - When it is used as design input to a safety-related activity or analysis

  For Example:

  - Input to a Thermal Life Calculations (used in the determination of the Qualified Life of Important to Safety Equipment)
  - Used to establish the initial starting temperature for a HELB analysis or a Thermal Lag Analysis

# Safety Classification

## When is Temperature Monitoring Data Considered to be:

- Non-Safety Related?
  - When it is not used as design input to a safety-related activity, document or analysis.

For Example:

- Used to monitor or confirm plant operating conditions remain within analyzed limits
- Assessing if a plant area contains hot spots or localized adverse condition

 

# Deciding Which Plant Areas to Monitor

- Plant Surveys can help to identify or eliminate the need for monitoring certain areas or equipment
- Surveys and Plant Walkdowns can be used to identify:
  - Areas where environmental stressors should be monitored
  - Relative position of equipment and heat sources
  - Confined areas and heat sources affecting equipment
  - Similarity or Differences in conditions between Units
  - Areas which have higher temperatures during outages
  - The appropriate monitoring method or instrument

# Deciding Which Plant Areas to Monitor

Focus on Areas that:

- Are subject to variations in temperatures due to:
  - Plant Power Levels or Modes
  - Seasonal Temperature Changes (ambient and UHS)
  - Thermal Stratification
- Normally have temperatures near the value used by EQ
- Contain Significant Heat Loads
  - High Energy Piping
  - Energized Equipment
- Have Limited Ventilation or Cooling
- Have Limited Access During Power Operation
- Have a High Population of EQ Components

# Deciding Which Plant Areas to Monitor

- Inside Containment
  - Subject to thermal stratification
  - High Potential for Local Hot Spot Conditions
  - Tech Spec Containment Temperature Limit is not always bounding / conservative since it is a volume weighted bulk average temperature.
- Outside Containment
  - With High Potential for Local Hot Spots
  - Areas that contain a large number of EQ components
  - Other Areas typically determined on a plant specific basis

 

# Identifying Hot Spots

## Typical Hot Spot Areas for PWR:

- Containment
  - Top of Containment (Upper Elevations)
  - Inside Bioshield
    - Near RPV Head / Vessel
    - Pressurizer Compartment
    - Near RCS Piping & Pumps
    - SG Compartments
  - Near CVCS Piping / Regen HX
  - Near SG Blowdown Piping

# Identifying Hot Spots

## Typical Hot Spot Areas for PWR:

- Outside Containment
  - MSIV / FWIV Valve Areas, Vaults, or Tunnels
  - Turbine Driven AFW Pump Rooms
  - Near High Temperature Piping Systems
    - Main Steam & Feedwater
    - Steam Line to AFW Turbine Driven Pump
    - CVCS Letdown Piping
    - SG Blowdown Piping
    - Auxiliary Steam Piping
  - Near Piping that is Heat Traced

 

# Identifying Hot Spots

## Typical Hot Spot Areas for BWR:

- Drywell
    - Can have significant thermal stratification
    - Near Recirculation Piping & Pumps
    - Near Main Steam Piping
    - Near Feedwater Piping

# Identifying Hot Spots

## Typical Hot Spot Areas for BWR:

- Secondary Containment
  - Steam Tunnel
  - Near High Temperature Piping Systems
    - Main Steam & Feedwater
    - Steam line to HPCI Turbine and RCIC Turbine
    - Near RWCU piping

# Deciding Which Equipment to Monitor

- Equipment that operates in an environment that is close to the temperature used by EQ to establish the Thermal Life
- Equipment that has a relatively short Thermal Life
- Equipment whose Thermal Life can not be extended to beyond 60 years using existing service temperatures
- Equipment subject to process fluid heating effects
- Equipment that would require significant resources to replace
    - Cables
    - Electrical Penetration Assemblies
    - ECCS Motors

# Considerations for Duration of TM

- Depends to Purpose of TM:
  - Is focus on peak temperatures only?
  - Is focus on average temperature conditions?
- Single or Multiple Refueling Cycle Period (18 – 24 months) for Plant Areas which are Inaccessible during Power Operation
- Annually for Plant Areas which are Accessible during Power Operation and see seasonal temperature variations

 

# Considerations for Duration of TM

- EPRI NP-7399 indicates that most TM durations vary between 6 months to 30 months.  Most common being 1 year and/or 1 refueling cycle
- EPRI 1021067 suggests that a 1 to 3 year period should be considered a minimum timeframe to ensure seasonal and operational variations are adequately incorporated

 

# Considerations for Duration of TM

- "Operational" and "Seasonal Conditions" can be more important than the duration of TM when looking for peak temperature conditions.
- Operational conditions include:
  - Plant Mode or Power Level
- Seasonal conditions include:
  - Variations in Outside air temperature conditions
  - Variations in Ultimate Heat Sink temperature
- Duration can be limited by:
  - Radiation limitations of digital monitors
  - Data storage capability of monitors

 

# Repeating or Revalidating TM

- Temperature Monitoring may warrant repeating or revalidating depending on the objective of the initial monitoring effort, the results of the initial monitoring effort or how the initial monitoring results were analyzed
- The need for future TM efforts can be influenced by:
    - How the results are used (confirmatory or to adjust QL)
    - Whether there is an established correlation between PI temperature elements and specific equipment locations
    - How much margin exists between the temperature used in the thermal life calculation(s) and actual service temperatures
    - If there has been changes in the plant that could affect normal temperature conditions (Configuration or Operational)

# Repeating or Revalidating TM

- Using TM results and adjusting the Thermal Life can introduce the need for future monitoring efforts when the normal ambient temperature used by EQ is less than the maximum design temperature
- Why is this?

  Plant operation above the EQ “limit” but below the Design “limit” may not be recognized by plant personnel as a potentially adverse condition affecting the Qualified Status of Equipment Important to Safety

# Repeating or Revalidating TM

- Temperature Monitoring provides a good indication of past operating conditions that may not always be representative of future operating conditions since it doesn't account for:
  - Design Changes / Mods implemented after the TM
  - Future Changes in HVAC performance (+/-)
  - Future Changes in Heat Loads (+/-)
  - Changes or Degradation of Thermal Insulation
  - Future Changes or Variation in UHS temperature
  - Changes in Online Plant Performance (+/-)
  - Impact from Extended Power Uprate

 

# Planning

## Considerations for Multi-Unit Sites

- Recognize that there can be temperature variations at the same location between Units
- Recognize that Operating History (e.g. % time on line) can be different between Units
- What can you do quantify these differences such that temperature monitoring in one Unit can be applied to another?
  - One Time Monitoring as part of finalizing scope & plan?
  - Use of PI monitors to quantify differences between units?
  - Use of additional margin/conservatism?

 

# Consideration of Plant Operating Conditions

- TM efforts need to cover variations in normal operating conditions
  - Power Operation
  - Startup / Shutdown
  - Outages (Refueling / Planned / Unplanned)
  - Infrequent Plant Operating Modes or Valve Lineups
- 100% Power Operation does not always result in highest equipment service temperatures or room temperatures
  - ECCS Pump Rooms (LPSI in operation for DHR)
  - RHR Pump Rooms (SDC mode for DHR)
  - SDC or RHR Heat Exchanger Rooms

 

# Consideration of Self Heating & Process Fluid Effects

Temperature Monitoring can define temperature rise due to process fluid effects

- Temperature Monitoring is not always able to define self heating effects of energized equipment
  - Has limitations on defining or validating self heating effects from energization (e.g. Cable Insulation, Motor Winding, Solenoid Coil, etc.)
- Good for defining or validating panel or cabinet temperature rise

 

# Consideration of Self Heating & Process Fluid Effects

- Some Equipment (such as solenoid valves) have specific temperature rise tests that establish temperature conditions of internal components (coil windings, valve body elastomers, etc.) under different service conditions
- These tests can include or address:
  - Normal Applied Voltage which affects temperature rise
  - Process Fluid effects
  - Variations in local ambient temperature conditions

 

# Choosing a Site TM Process

## What site process to use (to obtain TM data)?

**PERM INSTALLED (PI) DATA**

- Can Vary
  - N/A if already installed
  - Design Change if not already installed

**HAND HELD**

- Can Vary
  - Work Order
  - Maintenance Procedure
  - Engineering Procedure
  - Walkdown

**TEMPORARY MONITORS**

- Typically Varies
  - Temp Mod
  - Maintenance Procedure
  - Engineering Procedure
  - Housekeeping Procedure

# Selection of Monitors

# Selection of Monitors

## Monitors Typically Used in Temp Monitoring Include:

- Permanently Installed (PI) temperature elements
  - RTDs
  - Thermocouples
- Hand Held Devices
  - Digital Thermometers
  - Infrared (IR) Pyrometers
  - Contact Pyrometers
  - Thermography Camera
  - Thermocouple attached to Digital Multimeter

 

# Selection of Monitors

## Monitors Typically Used in Temp Monitoring Include:

- Temporary Monitors
  - Westinghouse LIFETIME
  - Westinghouse CITM Monitors
  - ACR Smartreader
  - ACR SmartButton
  - ACR OWL
  - HOBO Temp
  - Sensa Distributed Sensor System
  - Supco LTC LOGiT
  - Onset Stowaways

 

# Selection of Monitors

## Monitors Typically Used in Temp Monitoring Include:

- Other Methods
  - Temperature Paint
  - Thermal Strips or Stickers

# Selection of Monitors

## Use of Permanently Installed (PI) Temperature Elements

- Commonly found inside containment and other plant areas
- Typically provide general area temperatures
    - Containment Bulk Average Temperature Inputs
    - Containment Air Temperature (PAM)
    - Containment Sump Temperature (PAM)
- Current and Historical data available electronically for many PI temperature elements

 

# Selection of Monitors

## Use of Permanently Installed (PI) Temperature Elements

Selection and Use of PI temperature elements can include:

- Pressurizer PORV tail pipe temperature element
    - Intended for Leak Detection of PORV
    - Can indicate local ambient inside pressurizer area
- HVAC temperature elements (inlet / outlet air temps)
- Temperature Elements on Standby Equipment
    - ECCS motor stator temperatures (when not running)
    - ECCS motor bearing temperatures (when not running)

# Selection of Monitors

## Use of Permanently Installed (PI) Temperature Elements

- Can be very useful in evaluating temperature differences between Units
- Provides substantial temperature-time history information
- Not always representative of equipment service temperatures
- Good for monitoring and trending of ambient conditions
- Trending is much more effective when general area readings from PI temperature elements can be correlated to equipment temperatures

 

# Selection of Monitors

Use of Hand Held

Typically Used to Provide or Perform:

- Ambient or Contact Temperatures
- Surveys of Ambient Temperature Conditions
- Measuring Equipment Surface Temperatures
  - Process Fluid Effects
  - Self Heating Effects
- Detection of Local Hot Spots



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# Selection of Monitors

## Use of Hand Held

- Cross Correlation Between Equipment Temperature and;
  - PI Temperature Data
  - Temporary Monitor Data
- Easy to Use
- Typically part of plant's M&TE Program

# Selection of Monitors

## USE OF HAND HELD TEMPERATURE MEASURING DEVICES

- Digital Thermometer

# Selection of Monitors

## USE OF HAND HELD TEMPERATURE MEASURING DEVICES

- Infrared (IR) Pyrometer

# Selection of Monitors

## USE OF HAND HELD TEMPERATURE MEASURING DEVICES

- Thermography Camera


# Selection of Monitors

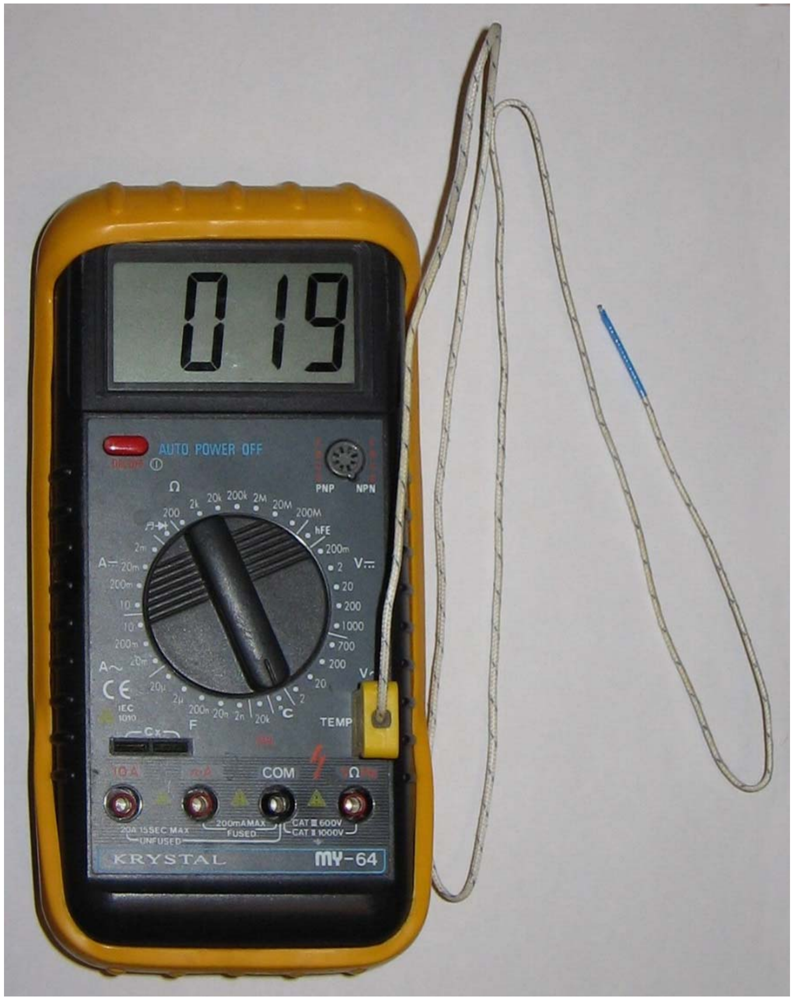
## USE OF HAND HELD TEMPERATURE MEASURING DEVICES

- Contact Pyrometer

# Selection of Monitors

## USE OF HAND HELD TEMPERATURE MEASURING DEVICES

- T/C with Probe



# Selection of Monitors

## Use of Temporarily Installed Monitors

- Commonly used inside containment as well as other plant areas (accessible and inaccessible)
- Can record local ambient or equipment temperatures
  - Max / Min Values
  - Temperature Time History
  - Arrhenius Equivalent
- A wide variety of monitors are available

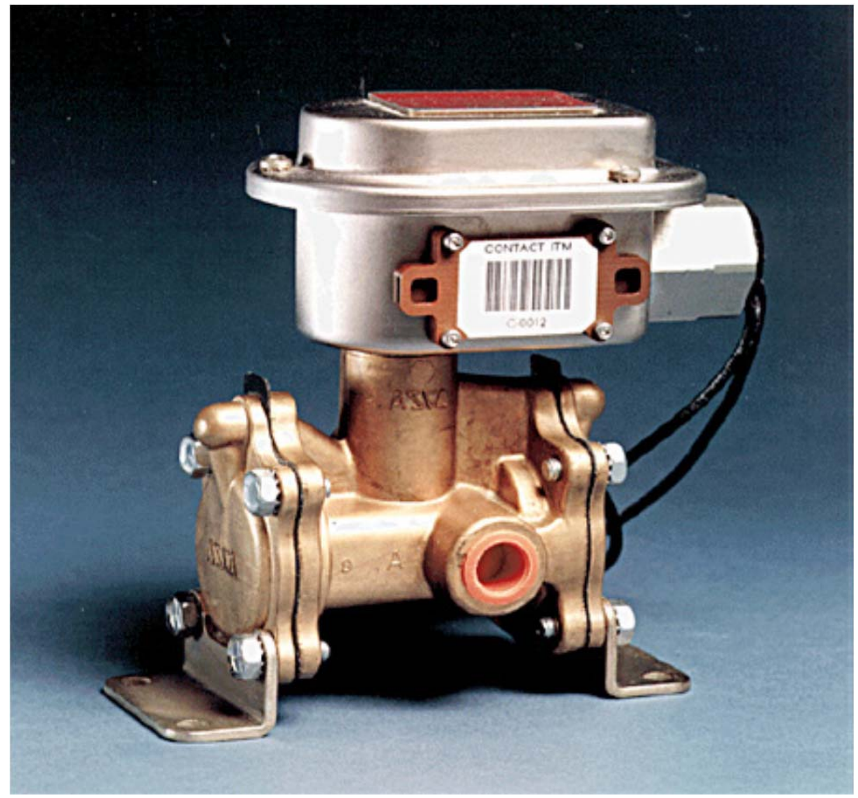
# Selection of Monitors

## USE OF TEMPORARY TEMPERATURE MEASURING DEVICES

- Westinghouse LIFETIME
  - Integrating Thermal Monitors
  - Provides "Arrhenius Equivalent" temperature
  - Can be used for prolonged periods
  - Largely immune to radiation and EMI/RFI effects
  - Can also measure gamma & beta doses and neutron fluences
  - Requires special handling and data reduction by Westinghouse (not readable by end user)

## USE OF TEMPORARY TEMPERATURE MEASURING DEVICES

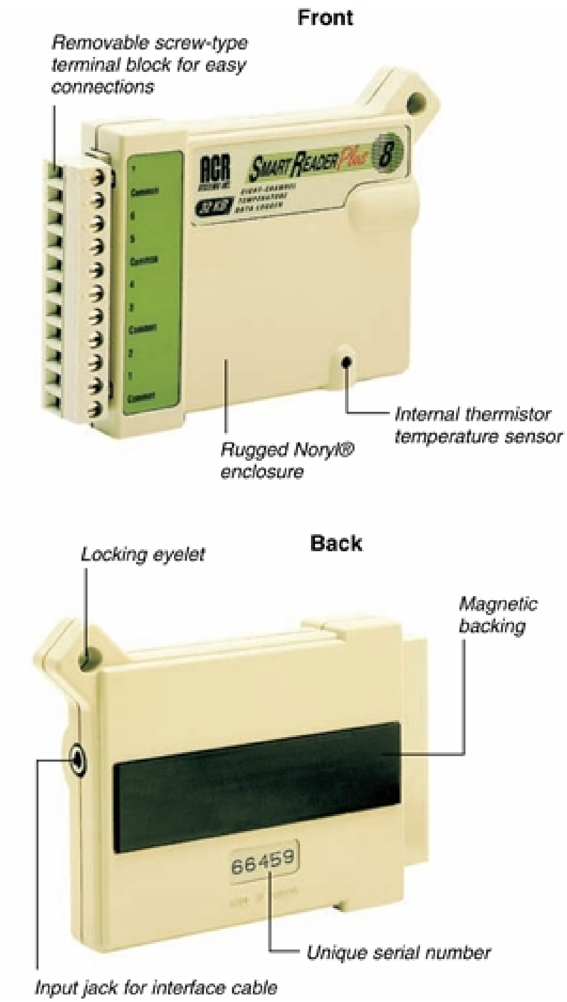
- Westinghouse CITM
  - Contact Integrating Thermal Monitors
  - Can be attached directly to the monitored equipment to measure surface temperature or placed inside equipment enclosures, panels, or cabinets.
  - Similar to LIFETIME monitors.



# Selection of Monitors

## USE OF TEMPORARY TEMPERATURE MEASURING DEVICES

- ACR SmartReader
  - Multi Channel Temperature (Thermistor) Datalogger
  - Mounting: Magnetic backing or eyelet
  - Temp Range: -40 to 70C
  - Battery: Lithium (10 yr life)
  - Memory: 3 sizes available
    - 32 KB - 21,500 readings
    - 128 KB - 87,000 readings
    - 1.5MB – 1,048,000 readings
  - Memory Modes: Wrap or Stop when full
  - Sampling: User Selectable



# Selection of Monitors

## USE OF TEMPORARY TEMPERATURE MEASURING DEVICES

- ACR SmartButton
  - Miniature sized temperature logger
  - Weight:  4 grams
  - Temp Range:  -40 to 85C
  - Battery:  Lithium (10 yr life)
  - Mounting:  magnetic backing, self adhesive backing
  - Memory:  2048 recordings
  - Memory Modes:  Wrap or Stop when full
  - Interface:  USB/ACR SmartButton interface

# Selection of Monitors

## USE OF TEMPORARY TEMPERATURE MEASURING DEVICES

- ACR OWL
  - Memory:  32,767 readings
  - Memory Modes:  Wrap or Stop when full
  - Battery:  Lithium (10 yr life)
  - Temp Range:  -40 to 70C
  - Sampling Rate:  User Selectable
  - Communication:  Optical data transfer
  - OWL 100 (internal temperature)
  - OWL 200 (internal & remote temp)

## Selection of Monitors

### USE OF TEMPORARY TEMPERATURE MEASURING DEVICES

- HOBO Temp Logger
  - Memory 84,650 measurements
  - Memory Modes:  Wrap or Stop when full
  - Temp Range:  -20 to 70C
  - LCD visible:  0 to 50C
  - Humidity Range:  0 to 95%RH
  - Battery Life:  1yr
  - Interface:  USB 2.0


Discontinued U10-001


Current UX100

# Selection of Monitors

## USE OF TEMPORARY TEMPERATURE MEASURING DEVICES

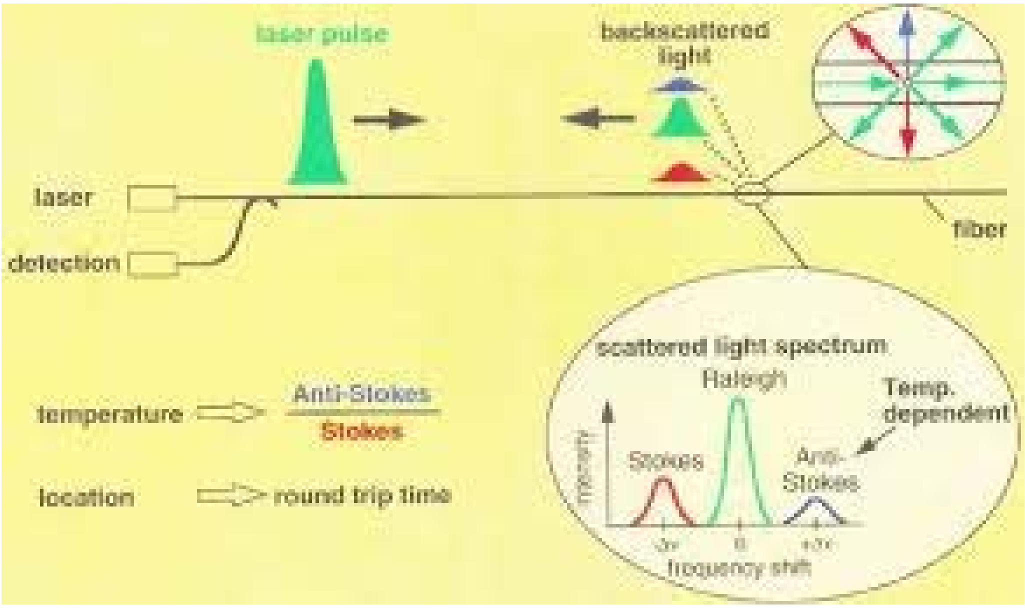
- HOBO U12
  - High accuracy for challenging process conditions
  - Memory:  43000 measurements
  - Battery Life:  3 yrs
  - Temp Range:  -40 to 125C
  - Readout: Direct USB interface

  Ideal for high temperature or submerged applications

# Selection of Monitors

## USE OF TEMPORARY TEMPERATURE MEASURING DEVICES

- Sensa Distributed Sensor System
  - A sensor in which an optical fiber is the transducer
  - Sensitivity extends over the entire length of the fiber



# Selection of Monitors

## USE OF TEMPORARY TEMPERATURE MEASURING DEVICES

- Onset StowAway
  - Miniature sized temperature logger
  - Weight: 19.5 grams
  - Temp Range: -20 to 70C (air)
    -20 to 30C (water)
  - Submersible: Rated to 1000 ft
  - Memory: 32,520 readings
  - Battery: 5 yr life (-20 to 50C)
  - Interface: Optical
  - Not suitable for prolonged exposure (> 8 weeks) to condensing environments


# Selection of Monitors

## USE OF TEMPORARY TEMPERATURE MEASURING DEVICES

- Supco LTC LOGiT
  - Thermocouple (Can be used with J, K, E, T, R, & S type T/Cs – software selectable)
  - Memory: 10,750 dual readings (internal and probe temperatures)
  - Interface: USB
  - Temp Range: 32F to 140F (logger)
  - Temp Range: -40F to 400F (probe)
  - Battery: 9V Alkaline or Lithium
  - Battery Life: 20 months Alkaline or 40 months Lithium

# Selection of Monitors

## Sampling Rates for Digital Monitors

- Digital Temperature Loggers digitize a continuous air temperature curve is recorded as discrete data points
- These data points are equally spaced along the abscissa
- This spacing is a function of the sampling rate
- The digitization by discrete sets of temperature/time information introduces error in replicating the actual temperature curve

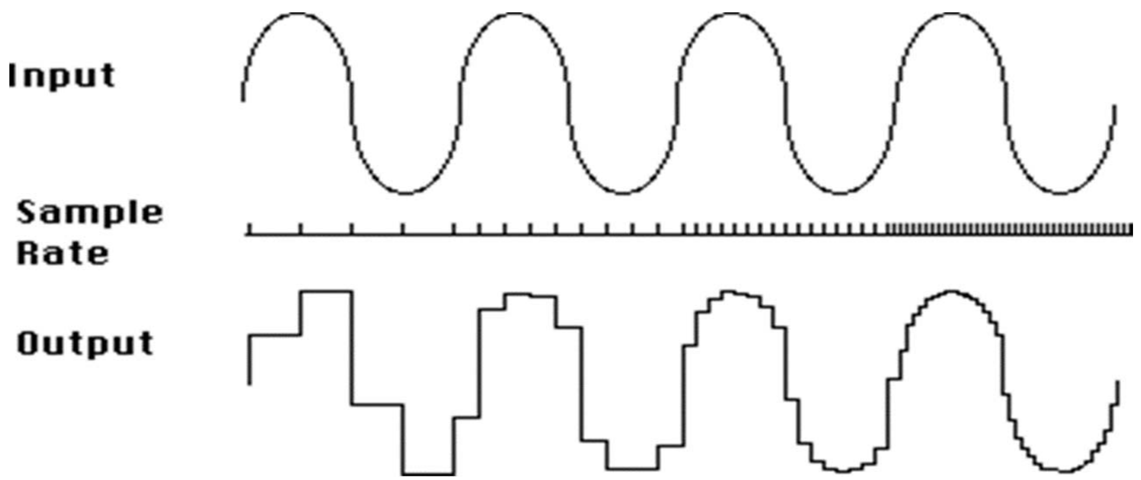
# Sampling Rates for Digital Monitors

- The "digitizing error" in fitting the actual air temperature curve by digital data can be expressed in terms of time interval (e.g. sampling rate) and the second derivative of the air temperature curve as follows:

$$|\delta T|_{max} \approx \frac{(\Delta t)^2}{8} \left| \frac{d^2 T_{air}}{dt^2} \right|_{max}$$

# Sampling Rates for Digital Monitors

- So higher sampling rates and smaller change rates of air temperature changes result in smaller digitizing errors




- For typical power plant areas, the steady state normal temperature conditions are fairly stable such that high sampling rates are not necessary to record peak temps

# Sampling Rates for Digital Monitors

- The Nyquist Sampling theorem states that the sampling frequency must be at least twice the highest frequency in the signal (e.g. Fourier series representation of the air temperature curve).
- If we exclude noise and other short term transients, the highest frequency can be approximated by the daily temperature variations over a 24 hour period
- Seasonal temperature variations are at a much lower frequency

# Sampling Rates for Digital Monitors

- Assuming the daily temperature variations (site ambient temperature) is approximated by a sine wave with a peak-to-peak period of 1/2 day, we would need a sampling rate of 4 times a day or higher.
- The memory capacity of most digital monitors supports much higher sampling rates for typical monitoring durations (2 year Refueling Outages)

# Sampling Rates for Digital Monitors

| Sampling Rate vs. Data Logger Memory Requirements | | | | | | |
|---|---|---|---|---|---|---|
| Sample Rate | | Proposed Temperature Monitoring Duration (yrs) | | | | |
| Readings (per day) | Readings (per hr) | 1 | 1.5 | 2 | 3 | 4 |
| | | Data Logger Memory Requirements (# of Readings) | | | | |
| 4 | 0.17 | 1460 | 2190 | 2920 | 4380 | 5840 |
| 8 | 0.33 | 2920 | 4380 | 5840 | 8760 | 11680 |
| 12 | 0.5 | 4380 | 6570 | 8760 | 13140 | 17520 |
| 24 | 1 | 8760 | 13140 | 17520 | 26280 | 35040 |
| 48 | 2 | 17520 | 26280 | 35040 | 52560 | 70080 |

# Advantages of Integrating Thermal Monitors

- Can be used over extended timeframes
- Relatively small and lightweight
- Immune to radiation effects
- Immune to EMI/RFI interference
- Provides Arrhenius Equivalent Temperature
- Can also measure dose (gamma, beta, neutron)

# Disadvantages of Integrating Thermal Monitors

- Higher Cost compared to other monitoring methods
- Requires Special Handling & Storage
- Not Directly Readable by Plant Personnel

# Advantages of Digital Based Monitors

- Relative Low Cost (Allows use of more loggers)
- Records Actual Temperature Time History
- Relatively Small and Lightweight
- User Selectable Sampling Rates
- Data download performed by user

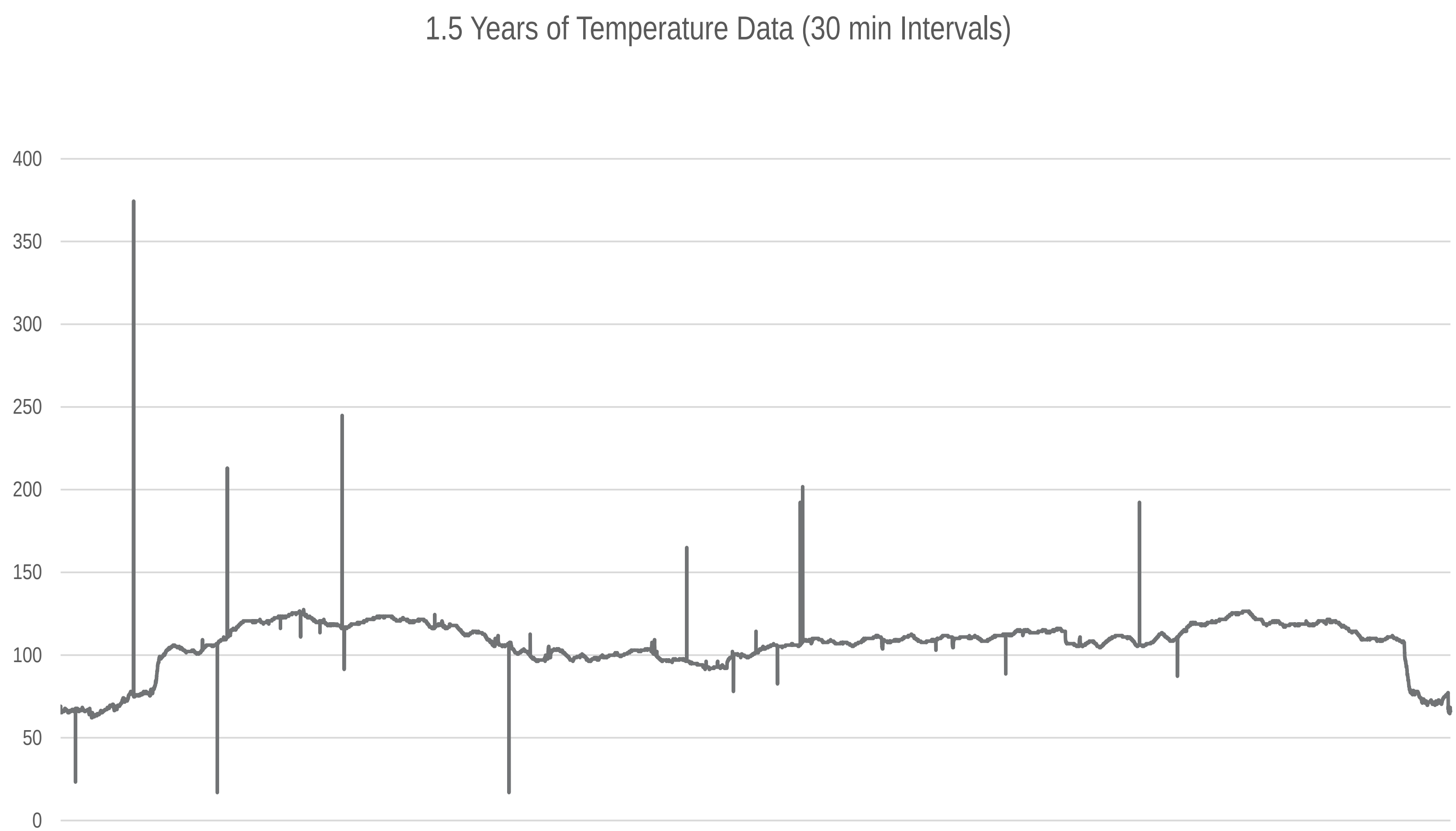
# Limitations of Digital Based Monitors

- Susceptible to Radiation (total dose & dose rate)
  - Can result in loss of data
  - Can result in saturated reading (constantly pegged high)
- Potentially Susceptible to Electrical Noise/Interference
- Finite Storage Capacity
- Finite Battery Life
  - Can Be reduced by higher Ambient Temperatures
  - Can Be reduced by Sampling Rate

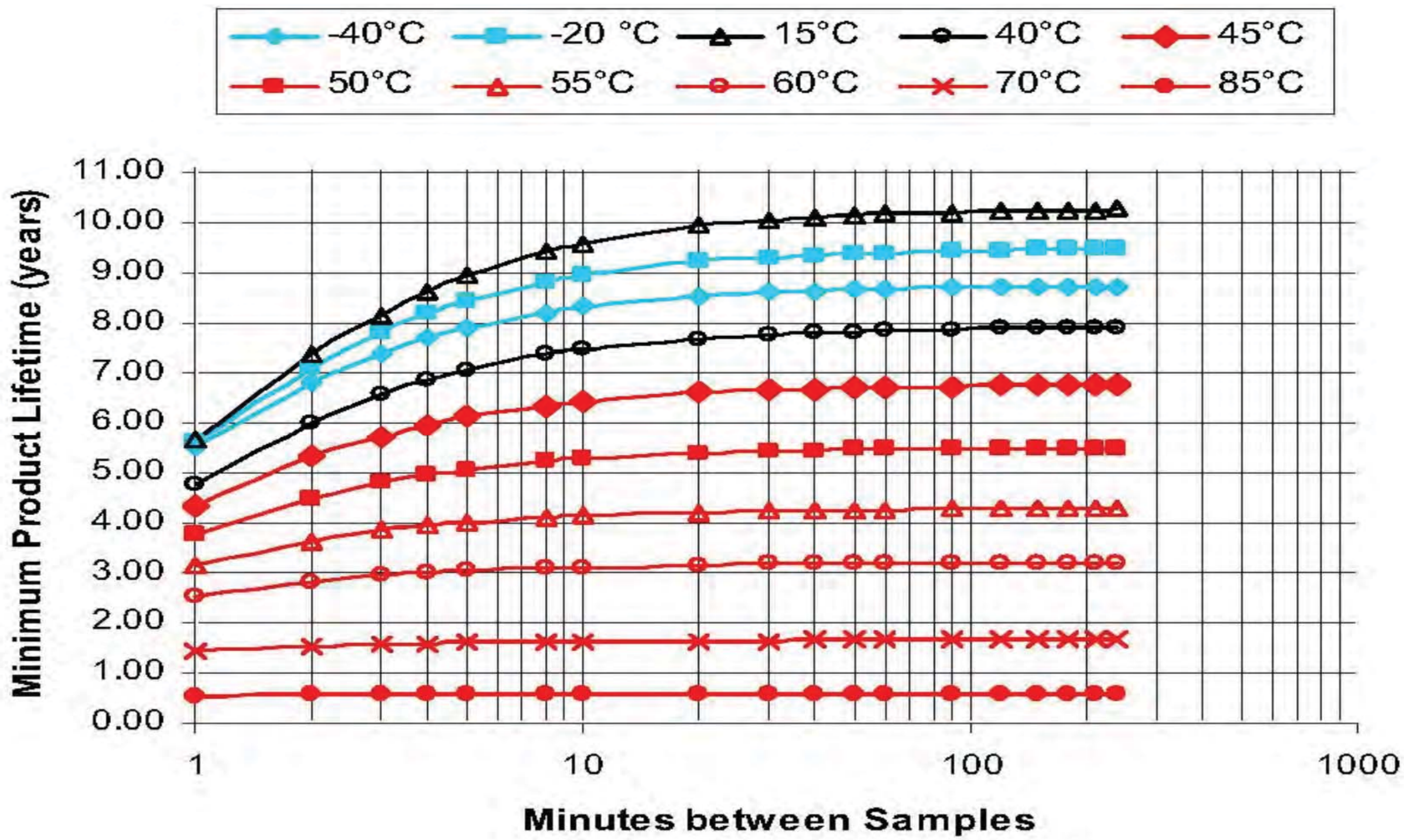
# Limitations of Digital Based Monitors

- Example of “Noise” on a Digital Datalogger



# Limitations of Digital Based Monitors

- Effect of Ambient Temperature & Sample Rate on Life



# Temperature Monitoring

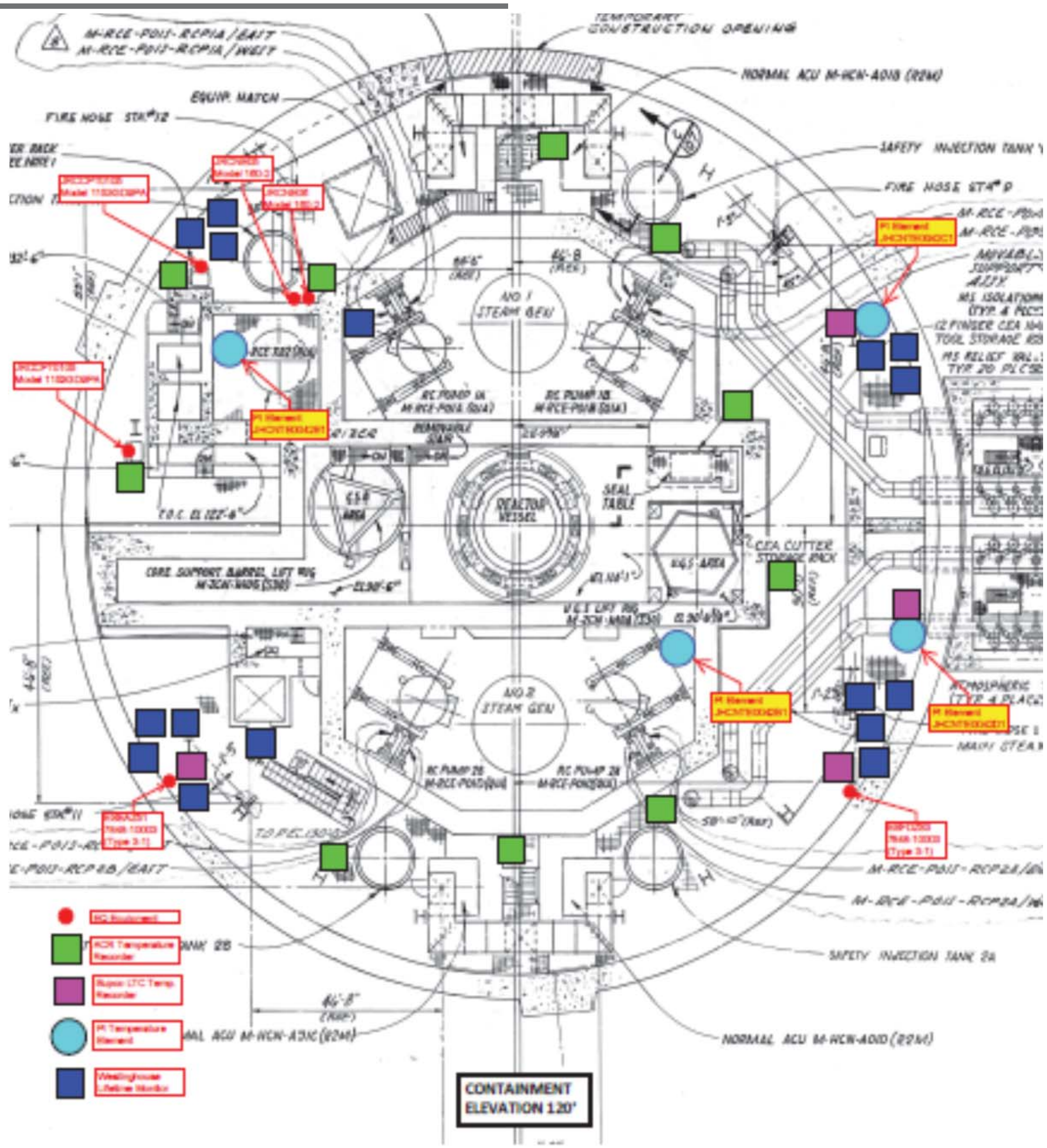
Time for Exercise #2

Selection of Monitors

(See Handout / Flashdrive)

# Installation Considerations



# Mounting Methods and Considerations

- There are multiple mounting methods available for temporarily installed monitors and loggers:
  - Adhesive backed
  - Magnetic backing
  - Metallic Wire
  - Cable Ties
- Provides flexibility in mounting:
  - In close proximity to equipment (local ambient)
  - On external surface of equipment
  - Internal to equipment enclosure, housing, panels, JBs, etc.

# Direct vs. Remote Measurement or Mounting

- Some monitors / loggers can support direct and remote measurements from the same device (multiple channels)
- Multi-Channel loggers can be advantageous for situations where there is a need to monitor local ambient and equipment surface temperatures simultaneously
- Remote Measurement can be advantageous for certain situations:
  - Placing digital monitor in less severe environment (temperature, dose, EMI/RFI, etc.)
  - Mounting to a local structure vs. equipment mounting

# Procedural Governance

- Temperature Monitoring activities need to be implemented in accordance with applicable site procedures & processes
- Procedural controls should cover:
  - What areas to monitor
  - What equipment to monitor
  - What instruments to use and how to calibrate them
  - Where and how to mount them
  - How to read or retrieve data
  - How to document the results

# Need for a 50.59?

- Typically Driven by Procedural Process Used
  - Installation via Temporary Modification
  - Installation via Existing Plant Procedure(s)
- Applicability or Screening may be performed when failure of temperature monitors / sensors:
  - Could produce debris loading on containment sump screens (for sensors inside containment)
  - Could adversely affect seismic qualification of equipment (externally or internally mounted)
  - Could adversely affect performance of equipment’s safety-related or important to safety function
- For additional guidance see RG 1.187 and NEI 96-07

# EMI / RFI Considerations

- Digital Monitors can be susceptible to electrical interference or noise
- Not normally an issue in most nuclear plant applications
- Potential for EMI/RFI interference should be considered when establishing the location of digital monitors or data loggers
- Digital Monitors or data loggers that have wireless data transfer / download capabilities should be appropriately evaluated as a potential interference source

# Dose and Dose Rate Considerations

- The accuracy of Digital Monitors can be influenced by dose or dose rate effects on their electronics
- Some ways to counteract these effects include:
  - Using Integrating Thermal Monitors in high dose / dose rate areas
  - Use of Remote Mounting to place electronics in lower dose areas
  - Use of Shielding or Placement of monitor behind structural elements that provide shielding

# Dose and Dose Rate Considerations

- Performing calibrations before and after monitoring would only address permanent or residual errors due to irradiation
- May not address any temporary errors that are only present during the irradiation exposure of a digital monitor.
- Some ways to counteract this effect include:
  - Limit use of digital monitors to locations where the total dose is below 1E+03 Rads over the monitoring period
  - Co-location of the digital monitor with an Integrating Thermal Monitor or Permanently Installed TE (to quantify the effect or demonstrate that there is no effect)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# Numbers of Monitors

- Using Multiple (2 or more) to monitor a given plant area is advantageous for a number of reasons:
  - Provides a better understanding of the temperature distribution within a room, compartment, or area
  - Provides a backup to unexpected sensor failure or loss
  - Provides a way to cross-reference results
- Having diversity in monitors can also be beneficial:
  - Use of PI or Integrating Thermal Monitors to backup a digital monitor

# Calibration Considerations

- Always a good engineering practice to use calibrated temperature monitoring instruments
- Typical practice is to calibrate before and after the monitoring period
- Use of Calibrated Measuring & Test Equipment (M&TE) is required when TM results will be used in a safety related manner
- Instrument Calibrations are traceable to National Institute for Standards and Technology (NIST) - formerly National Bureau of Standards (NBS)
- Calibration is current at time of use for TM monitors (e.g. instruments, sensors, & probes)

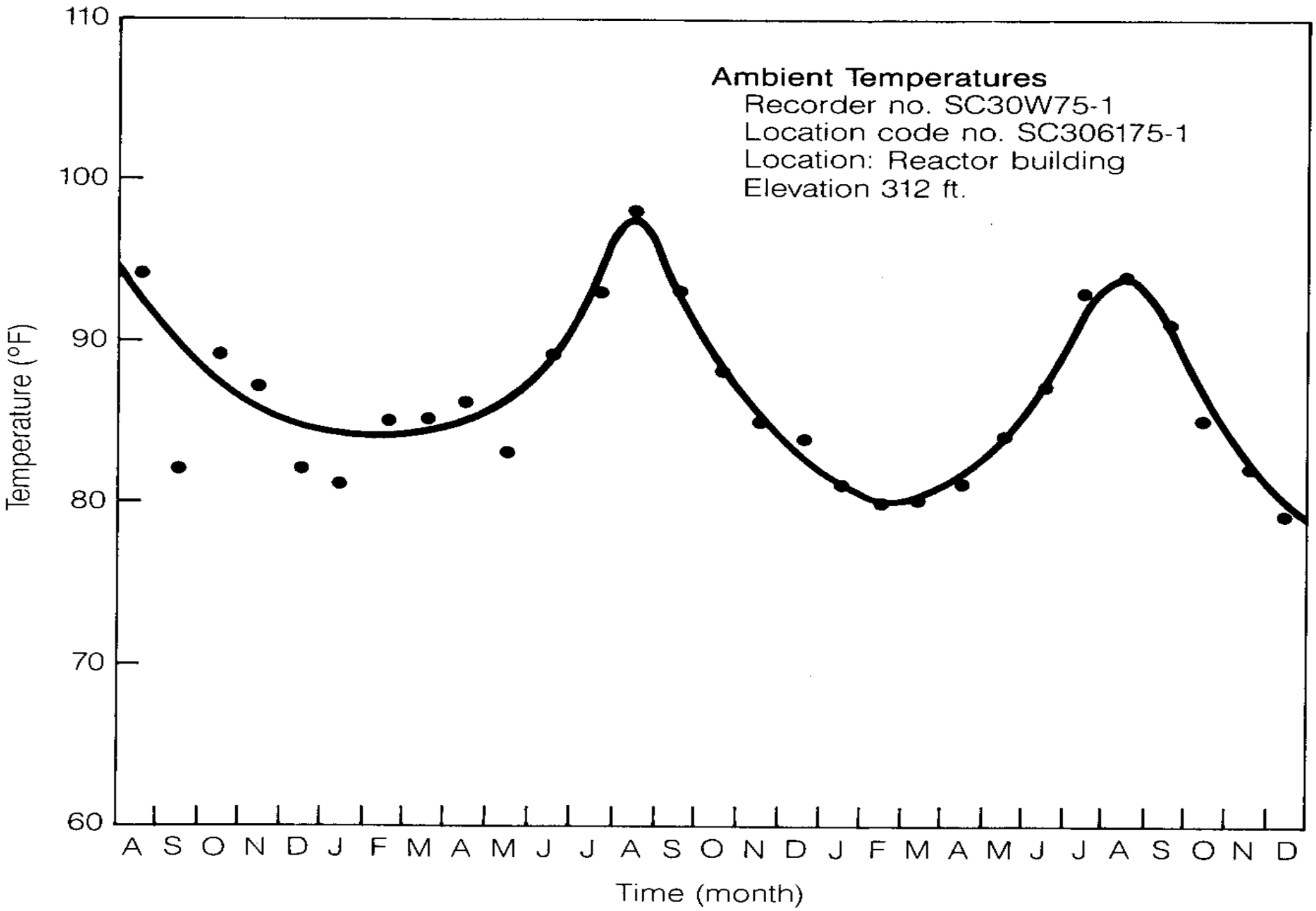
# V & V of Software (Used to Calibrate Digital Monitors)

- Digital Based Temperature Monitoring Devices typically use software as part of the calibration process
- Need to recognize that this software is not normally developed and controlled under an approved nuclear QA Program
- This can raises questions regarding the need to perform V&V on the software
- TM Programs using Digital monitors should always ensure that they are complying with the stations policies & procedures regarding V&V of software

# V & V of Software (Used to Calibrate Digital Monitors)

- The following activities can be used to confirm that the software is functioning properly:
  - Calibration of the data loggers against NIST/NBS standards
  - Cross comparison of readings against other calibrated temperature monitors

# Analyzing the Results



# Analyzing the Results

- Temperature Monitoring (TM) Programs can produce a vast amount of raw data in digital form
- Analyzing the results can be a labor intensive challenge even when using computerized software tools to evaluate the data
- Approach typically involves balancing:
  - Accuracy
  - Conservative Simplifications
- Record Retention is another consideration that can influence how the analysis is done or documented
  - Digital Data vs. Hard Copy

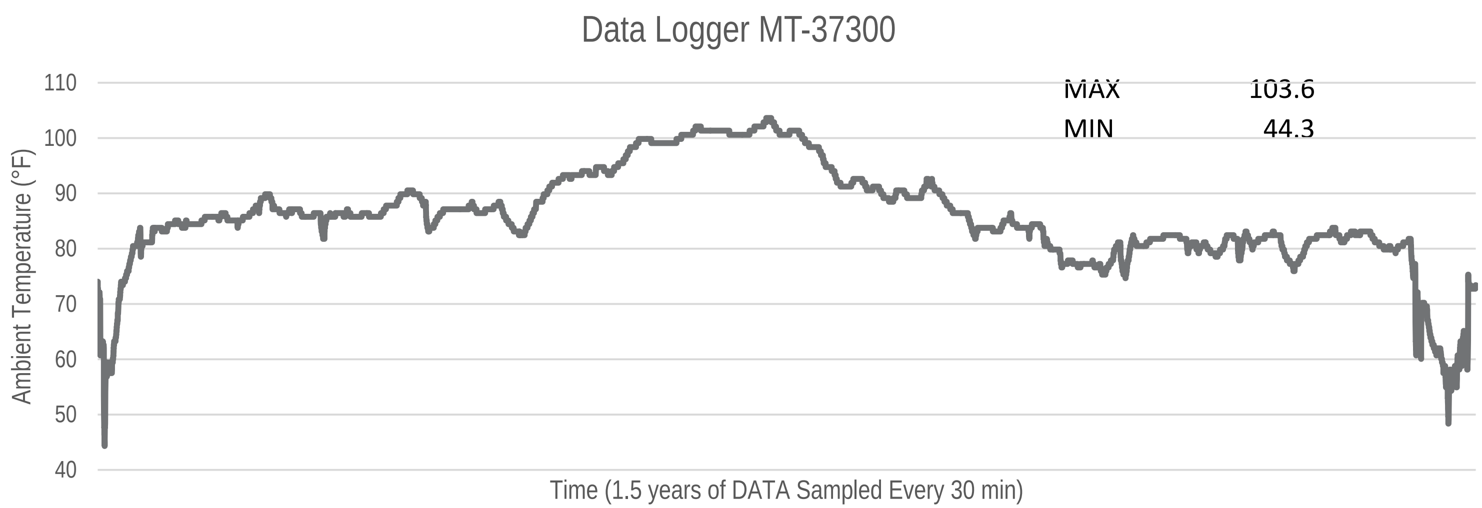
 

# Validation of Results

- Needs to be done before analyzing the temperature data
- Temperature data sets from each sensor should be scanned/reviewed to
  - Are all of the data loggers readable?
  - Do we have the expected number to data points?
  - Are the temperature results reasonable?
  - Is there any evidence of noise in the data?
  - Was any erroneous or suspicious data identified?

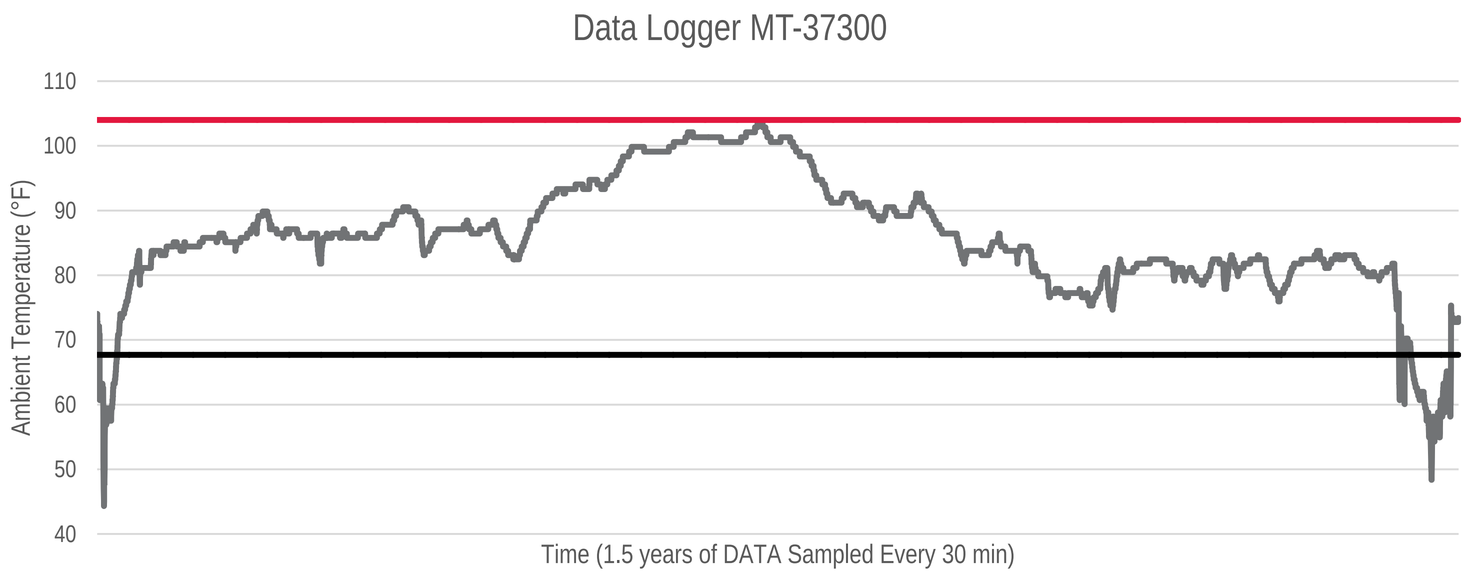
# Validation of Results

- Some suggested initial actions in validation would include:
  - Plotting the data
  - Getting Max / Min Temperatures



# Validation of Results

- Some suggested initial actions in validation would include:
  - Visually comparing the temperature profile against:
    - The 2-Sigma above the Arithmetic mean temperature
    - The 2-Sigma below the Arithmetic mean temperature



# How Much Analysis Is Needed?

- This can vary widely depending on the both the objective of the TM as well as the results
- For Example:
  - Little to no additional analysis would be needed for a TM activity that is looking to validate that service temperatures are below maximum design levels and the maximum temperature in the data is well below the design value
  - Additional analysis may be warranted when maximum (or peak) temperatures are found to exceed the value used by EQ to establish the Thermal Life

# Treatment of Erroneous or Suspicious Data

- The ID and Disposition of any suspected erroneous or suspicious data should be documented
- This includes:
  - Missing or Loss of Data points
  - Random Instantaneous Spikes (+/-)
  - High Frequency Oscillations (Electrical Noise)
- Disposition Actions can include:
  - Continued use of data
  - Modification of the data points (e.g. filtering, interpolation, etc.)
  - Rejection of discrete data points
  - Exclusion of results from the Data Logger in question

# Treatment of Erroneous or Suspicious Data

- The disposition of any Suspect Data should:
  - Consider if the temperature data point(s) is well beyond the known instrument accuracy or response time
  - Consider daily, monthly or seasonal temperature variations
  - Changes in Plant Operating Modes
  - Changes in Plant Operating Conditions
  - Changes in Plant Ultimate Heat Sink (UHS) temperature
  - Consider if the data accurately reflects a temperature excursion (steam leak, loss of HVAC, etc.)

# Handling Noise or Electrical Interference in the Data

- Can be the result of:
  - Electrical Interference of nearby equipment
  - 60 Hz AC noise
- Recognize that noisy data or random data can also be produced by events other than electrical interference
  - Radiation Effects on electronics
  - Failure of discrete electronic components
  - Low battery conditions

# Handling Noise or Electrical Interference in the Data

- Can be cross-checked against other monitors in the same area to determine if the reading is valid or not
- Intermittent or Random Noise Events can simply be excluded
- Constant Noise Events:
  - Can result in exclusion of that data logger from further analysis
  - Can be evaluated for frequency content and filtered out

# Treatment of Outage Temperature Conditions

- Normal Temperatures can decrease significantly in some plant areas when the plant is in cold shutdown or refueling modes
- There can be situations where Normal Temperatures stay the same or increase slightly when the plant is in cold shutdown or refueling
- While the outage temperature conditions may be representative of future conditions, it should be recognized that the percentage of outage time may not be representative of future plant performance

# Treatment of Outage Temperature Conditions

- How outages are considered can influence how the results are analyzed
  - Will the outage conditions be included to reflect actual historical data?
  - Will the outage conditions be excluded to reflect optimal plant performance in the future?
  - Will the analysis include the determination of normal temperature conditions with & without outage data?
  - Will the outage temperature conditions be truncated for all temperatures below a certain value?

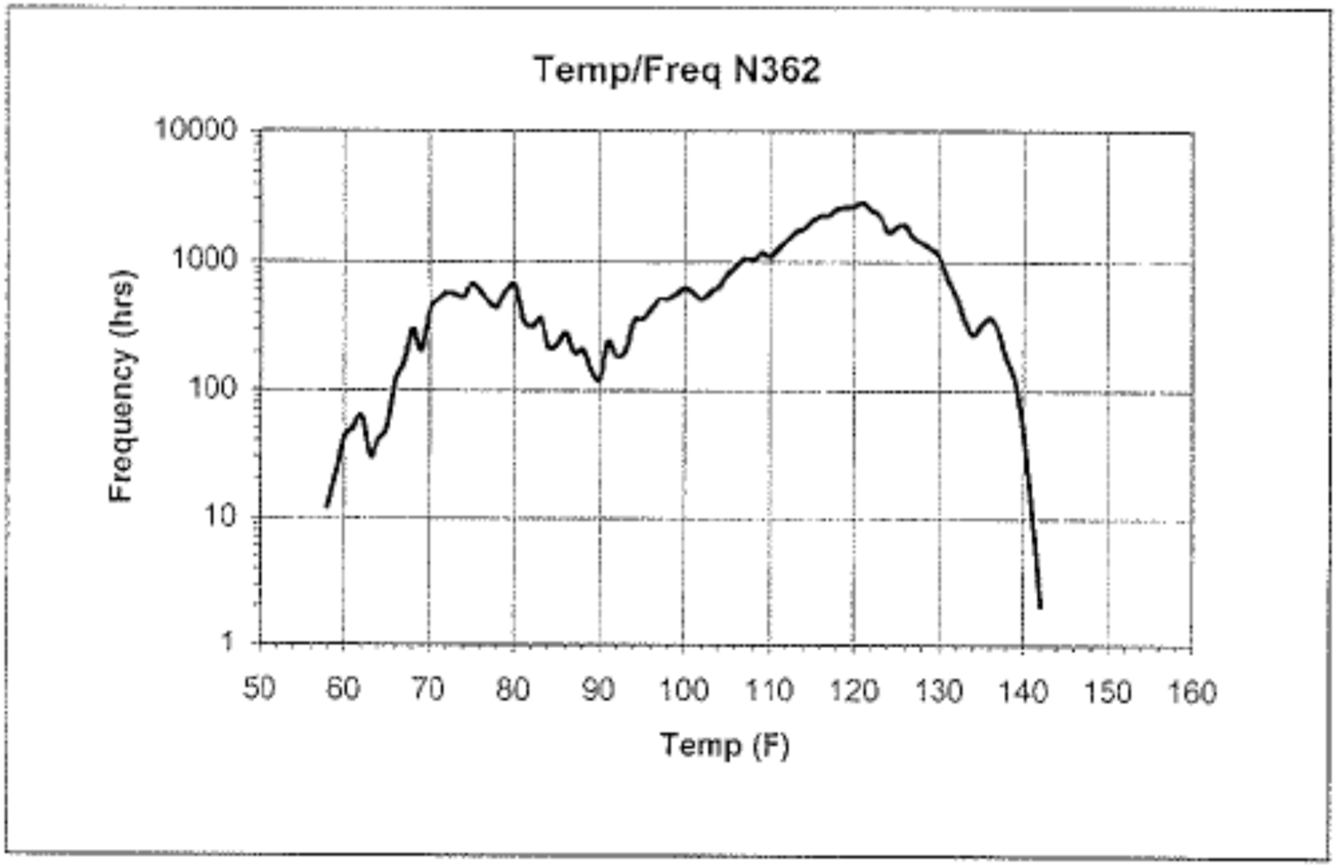
 

# Mathematical Analysis

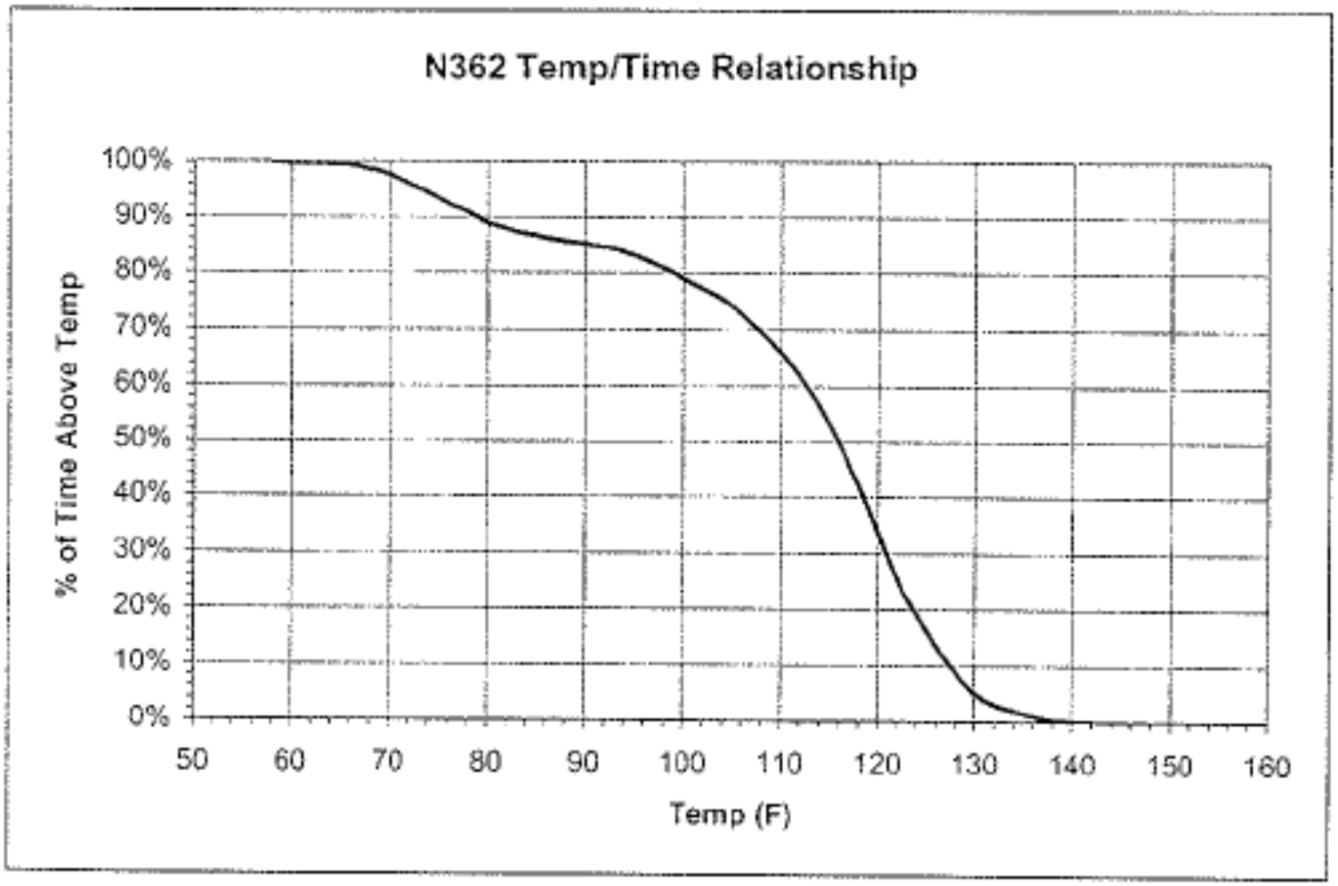
- Typical Statistical Analysis of Results includes determining:
  - Maximum and Minimum Temperatures During Period
  - Arithmetic Mean Temperature During Period
  - Standard Deviation of Mean Temperature
- Some Additional analysis that can be performed includes:
  - Temperature / Frequency Histogram
  - % of Time Above a Temperature or Temperature Range
  - Arrhenius Equivalent Temperature
  - Fast Fourier Transform (FFT)

# Statistical Analysis (Example of Histogram)



# Example of % of Time Above a Temp Plot



# Use of Arithmetic Weighted Average Temperature

- The Time Weighted Average Temperature can be used to define a single temperature that is representative of the measured temperature time history
- Time Weighted Average Temperature for a set of normal service temperature data is usually lower than the results obtained using the Arrhenius Equivalent Temperature
- This difference typically varies between 1˚F and 6˚F and is usually bounded by a 2-Sigma (95% confidence level) being applied to the Weighted Average Temperature

# Use of Arithmetic Weighted Average Temperature

- The ability to quantify the difference between the Weighted Average Temperature and Arrhenius Equivalent Temperature will require consideration of:
  - Activation Energy
  - No. of Temperature Data Sets
  - No. of Temperature Intervals
  - Overall Range of Temperature Intervals
  - Distribution of Data Sets in each Temperature Interval

# Use of Arrhenius Equivalent Temperature

- A form of the Arrhenius equation is commonly used to develop a constant temperature value that produces the same thermal degradation that would result from exposure to the measured temperature time history
- Also referred to as the Arrhenius Degradation Equivalent Temperature

# Use of Arrhenius Equivalent Temperature

- Typical form of the Arrhenius Equation is:

$$Life_1 = Life_2 \cdot \exp\left[\frac{\phi}{\kappa} \cdot \left(\frac{1}{Temp_1} - \frac{1}{Temp_2}\right)\right]$$

where:

$\phi$ = activation energy (eV)
$\kappa$ = Boltzmann's constant (8.617E-5)
Temp = Temperature in degrees Kelvin

# Use of Arrhenius Equivalent Temperature

- Expanding the Exponential expression gives:

$$Life_1 = Life_2 \cdot \frac{\exp\left(\frac{\phi}{\kappa} \cdot \frac{1}{Temp_1}\right)}{\exp\left(\frac{\phi}{\kappa} \cdot \frac{1}{Temp_2}\right)}$$

# Use of Arrhenius Equivalent Temperature

- Substituting

  $L_1$ for $Life_1$

  $Freq_1$ for $Life_2$

  $T_e$ for $Temp_1$

  $T_1$ for $Temp_2$

- The variable “Freq” can be used for a “time/temperature” data set and the data is analyzed by a “frequency” function (which identifies the number of times a specific temperature is measured)
- Using the max temperature for each day, the frequency at that temperature is equal to a duration.

# Use of Arrhenius Equivalent Temperature

- Which can be expressed as:

$$L_1 = Freq_1 \cdot \frac{\exp\left(\frac{\phi}{\kappa} \cdot \frac{1}{T_e}\right)}{\exp\left(\frac{\phi}{\kappa} \cdot \frac{1}{T_1}\right)}$$

and

$$L_2 = Freq_2 \cdot \frac{\exp\left(\frac{\phi}{\kappa} \cdot \frac{1}{T_e}\right)}{\exp\left(\frac{\phi}{\kappa} \cdot \frac{1}{T_2}\right)}$$

etc. to "n" for $T_n$ different temperatures

# Use of Arrhenius Equivalent Temperature

- Which can be expressed as:

$$T_e = \frac{1}{\frac{\kappa}{\phi}\cdot\ln\left(\frac{\text{Interval}}{\sum_{i=1}^{n}\frac{\text{Freq}_i}{\exp\left(\frac{\phi}{\kappa}\cdot\frac{1}{T_i}\right)}}\right)}$$

Where $T_e$ is in degrees Kelvin.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# Use of Arrhenius Equivalent Temperature

- Which can be rearranged as:

$$T_e = \frac{\phi}{k}\left(\frac{1}{-\ln\left(\sum_{i=1}^{n}\left(\%\,time_i * e^{\left(\frac{-\phi}{k*T_i}\right)}\right)\right)}\right)$$

Where $T_e$ is in degrees Kelvin.

 

# Use of Arrhenius Equivalent Temperature

- In order to make the resulting Arrhenius Equivalent Temperature independent of the equipment or materials in the area, we need to select a conservative activation energy
- Conservative in this case means a higher Arrhenius Equivalent Temperature
- Which means we need to select an Activation Energy that is equal to or higher than most common materials

# Use of Arrhenius Equivalent Temperature

- An Activation Energy of 2.0eV or higher is commonly used for this type of analysis.
- This is supported by the histogram of activation energies for typical materials used in EQ applications

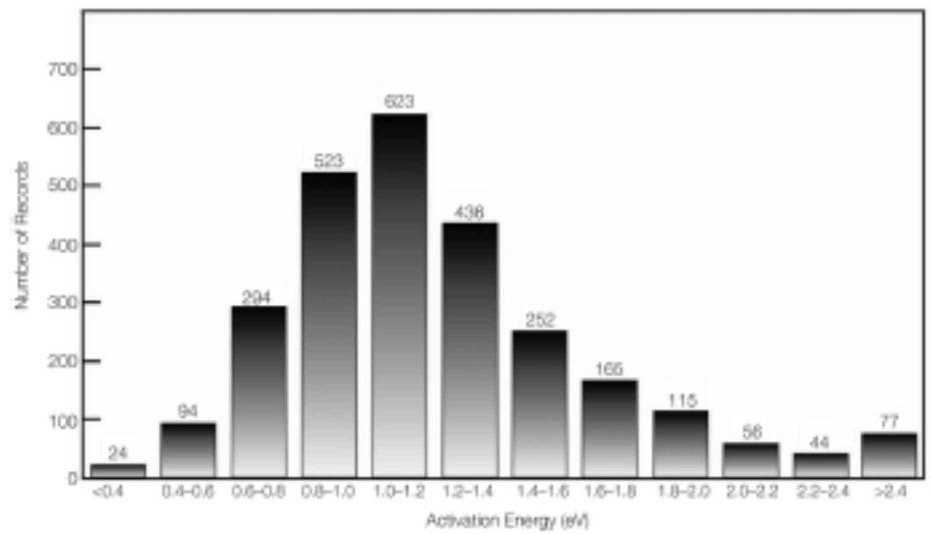


**Figure G-2**
**Histogram of activation energy values (from the Equipment Qualification Database) [G-4]**

 

Time for Exercise #3

Case Study

Analysis of Temperature Data

(See Handout / Flashdrive)

# Application of Margin to Accommodate Future TM Efforts

- There is inherent uncertainty in applying temperature monitoring results as representative of actual service temperatures in the future.
- Temperature Monitoring Programs have addressed this in a variety of different ways
- Typically, the approach involves the application of some level of conservatism above the historical temperature readings

 

# Application of Margin to Accommodate Future TM Efforts

- Examples of ways in which conservatism is applied includes:
  - Applying additional margin above the Arrhenius equivalent temperature (2°F to 5°F)
  - Use of max temperature for the day/week/month and determining the Time Weighted Average Temperature or Arrhenius Equivalent Degradation Temperature
  - Conservative assumptions in deriving the Temperature Frequency Distribution (Max Temp for all data in a Bin)
  - Selection of a normal service temperature that bounds 95% of all of the data (2-sigma)
  - Ignoring Lower Temperatures due to Outages



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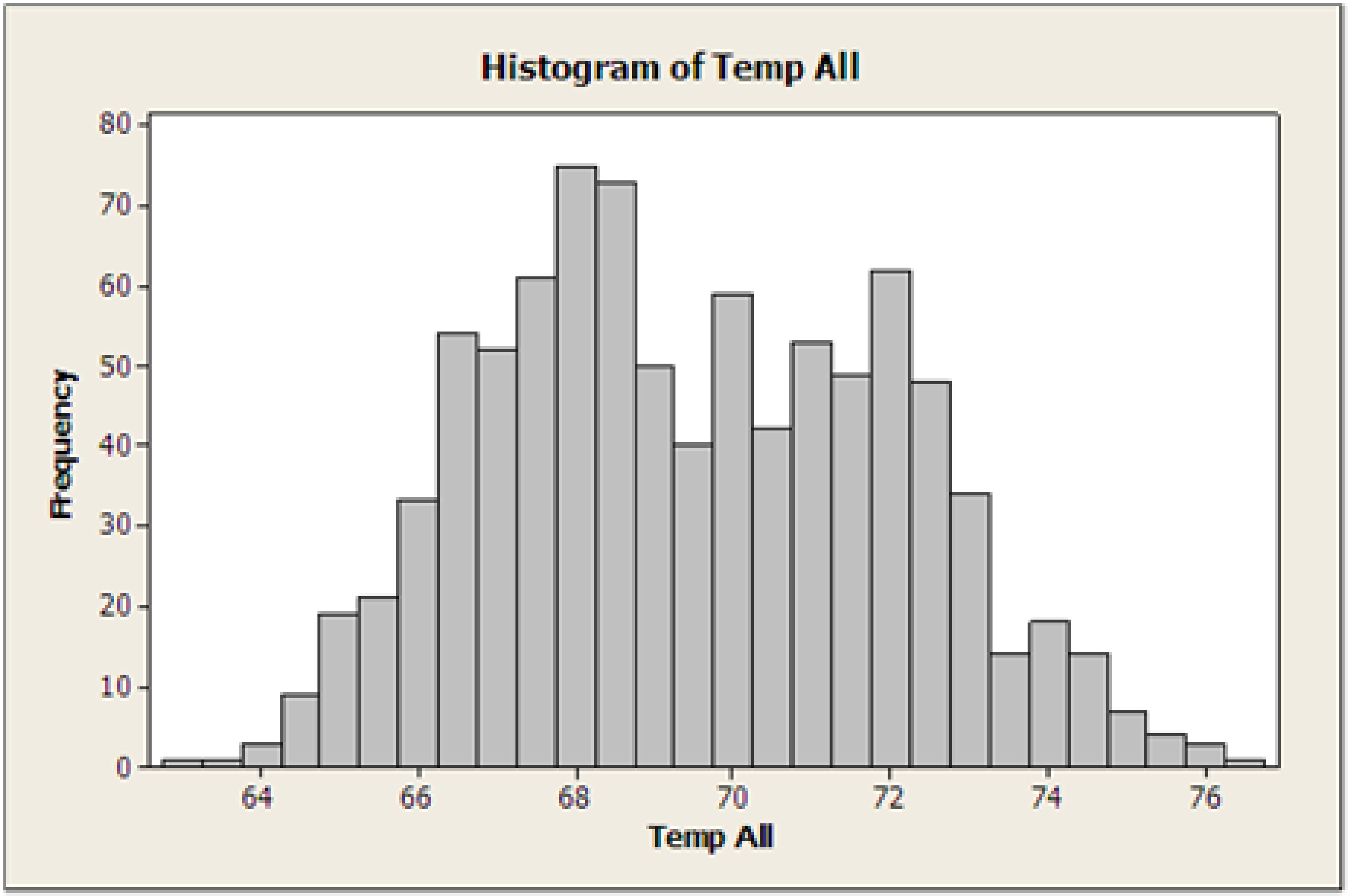
Time for Exercise #4

Selection of Normal Temperature

(See Handout / Flashdrive)

# Documenting the Results



# Documenting the Results

- The intended purpose of the TM effort will largely determine how the results will be documented
    - Safety Related or not?
    - Plant Record or Revision Controlled Document
- The potential for future TM efforts can also be a consideration on how the document is structured/formatted
- The results and conclusions should be tailored to support the intended use by the “end user”

# Documenting the Results

- Types of Information to Record in addition to the raw temperature data:
  - S/N of Monitor(s)
  - M&TE Number of Monitor(s)
  - Location
  - Time/Date of Installation and Removal
- For Hand Held Monitors
  - Who Took the Data
  - Whether the Data was independently verified.

# Documenting the Results

- Other Potentially Relevant Information to Record includes:
  - Work Order # (if applicable)
  - Procedure No. & Revision Level (if applicable)
  - Plant Power Level or Mode
  - Site Ambient Temperature (Met Tower Info)

# Documenting the Results

- Results of Temperature Monitoring efforts that are intended as input to the reanalysis of thermal life should consider or include:
  - Defining what the historical temperature conditions are based on the monitoring performed to date
  - How the measured temperature conditions could be different in the future
  - Identifying any local hot spot conditions
  - Describing any adjustments made to the data (e.g. addition of calibration tolerance, statistical bias, variability between units, filtering, etc.)

# Temperature Monitoring

Time for Exercise #4

Selection of Normal Temperature

(See Handout / Flashdrive)

# Documenting the Results

- Results of Temperature Monitoring efforts can also be useful for activities other than updating the thermal life of EQ equipment
- For Example:
  - Trending performance of systems (e.g. HVAC)
  - Statistical Data can be useful in future Operability Determinations

# Application of the Results

Some considerations and cautions regarding application of Temperature Monitoring results:

- Aging analysis, including the Arrhenius methodology for evaluating thermal degradation, is not an exact science
- The Arrhenius is intended to provide a conservative extrapolation of the accelerated aging that was performed to simulate an end of life condition during the qualification test program prior to exposure to simulated DBA conditions
- Qualified Lives established from qualification test programs are intended to be supplemented by a feedback mechanisms (e.g. Operating Experience, Corrective Action Program, Maintenance and Surveillance activities, etc.) [RG 1.89 Section C.5.d]

# Application of the Results

## Temperature Monitoring Results:

- Can Support Definition of Normal Service Temps
- Can Quantify Thermal Stratification (Normal Operation)
- Can Establish if Equipment is subject to local Hot Spots
- Can Validate Currently Defined Thermal Life
- Can Extend Thermal Life
- Can Shorten Thermal Life
- Can Support 1-time EQ PM extension/deferrals
- Can Support Reanalysis of TLAA
- Can Be a Leading Indicator for Equipment CM

# Application of the Results

## Temperature Monitoring Results:

- Not Necessarily Limited to EQ Equipment
- Can Quantify Seasonal Temperature Variations
- Can Quantify Effort of Changes in Plant Modes
- Can Assist in Evaluating Temperature Excursions

## Can also be used to Detect:

- Changes in Performance of HVAC Systems
- Degradation in Thermal Insulation
- Changes in Normal Temps due to Design Changes

Time for Exercise #5

Reanalyzing the Thermal Life

(See Handout / Flashdrive)

# Survey Finalization

- Major Topics
- Proposed Schedule
  - Issue by November 20, 2015
  - Establish Sharepoint Site/Information & Document Exchange portal
  - Weekly reminders and response tallies starting December 4, 2015
  - Close Survey January 8, 2016
  - Issue Survey Report by January 22, 2016
  - All class attendees and responders will receive copy of the Survey Report

# Closing Remarks

- There are many ways in which a Temperature Monitoring Program may be implemented
  - The material and exercises covered in this class provide some examples of how this could be accomplished
  - There can be other methods and approaches that achieve the purpose and objectives of a TM Program
- Temperature Monitoring represents a effective way to confirm/verify that Important to Safety equipment is exposed to temperature conditions that remain within the analyzed or design limits

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