NUCLEAR NEW HORIZONS:
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October 21-25, 2019 | Mendes Convention Center | Santos, SP, Brazil

SAMPLE SIZE METHODOLOGIES IN AGING MANAGEMENT PROGRAMS

Rennan de Souza da Silva[1], Lucas Casagrande Monteiro[1,2] and Luiz Henrique de Freitas Almeida[1,2]

[1] Eletrobrás Termonuclear S.A. - ELETRONUCLEAR
Diretoria de Operação/ Núcleo Técnico – LTO Angra 1
Central Nuclear Almirante Álvaro Alberto
Rodovia Procurador Haroldo Fernandes Duarte, BR101/RJ,S/N km 521,56
CEP: 23948–000, Itaorna, Angra dos Reis, RJ, Brazil
rennan@eletronuclear.gov.br, luizhf@eletronuclear.gov.br

[2] Centro Federal de Educação Tecnológica Celso Suckow da Fonseca, Campus Angra dos Reis,
Rua do Areal, 522
CEP 23953-030, Angra dos Reis, RJ, Brazil
lucas.monteiro@aluno.cefet-rj.br, luiz.almeida@aluno.cefet-rj.br

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Aging Management Programs

An Aging Management Program (AMP) consists of a series of activities (e.g. inspections, tests) for managing the effects of aging on Structures, Systems and Components (SSC) to assure that these SSCs are able to perform their intended function, during the period of extended operation, ensuring safe plant shutdown, without risk to the environment or the population.

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Introduction

Determining a sample size to assure that a defect will be detectable; according to the desired confidence level is an essential task in the development of an inspection program.

NUREG 1801 - Generic Aging Lessons Learned (GALL) Report, revision 2 [1]; defines most of its programs sample size, however for a few cases, especially the ones related to SSCs (Structures, Systems and Components) not related to safety the sample size is not clearly set.

This work presents a methodology based on EPRI–TR-107514 - Age-Related Degradation Inspection Method and Demonstration: In Behalf of Calvert Cliffs Nuclear Power Plant License Renewal Application [2].

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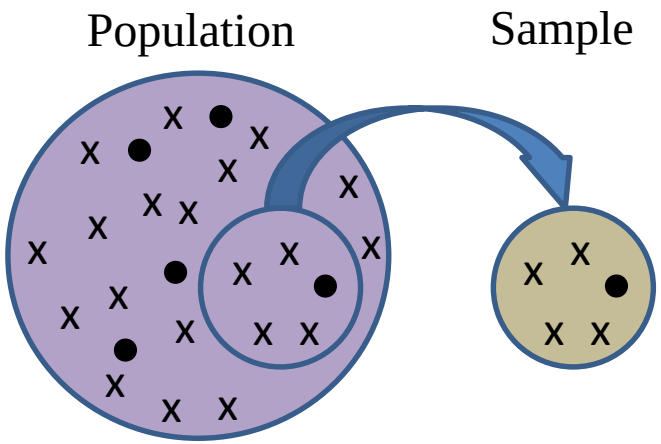
Importance of Sampling



• It is not always possible or convenient to evaluate all elements of a population due to;

- Radiation Exposure
- Time
- Cost
- Technical Feasibility

A Sample can decrease the number of inspected structures, equipment and components ensuring the detectability of a defect, with the required level of confidence.

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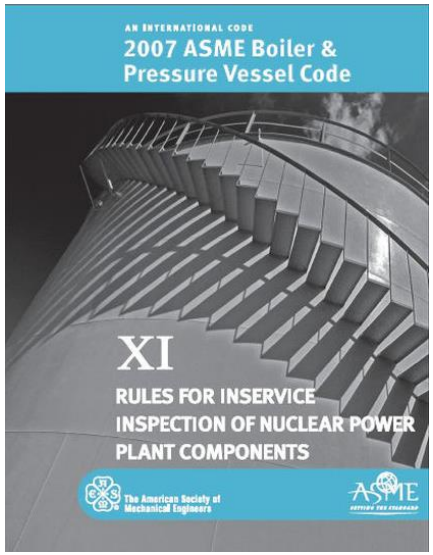
Sampling Bases

NUREG-1801: GALL – GENERIC AGING LESSONS LEARNED

Determines the sampling criteria for each program.



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Examples of Programs which uses one or both methods:

- XI.M35 - ONE-TIME INSPECTION OF ASME CODE CLASS 1 SMALL-BORE PIPING

- XI.M18 – BOLTING INTEGRITY

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Sampling Bases

According to EPRI–TR-107514 [2], for a finite population the confidence parameter (z_α) is:

$$\pm z_\alpha = \frac{X - np}{\sqrt{np(1-p)}\sqrt{\frac{N-n}{N-1}}}$$

X = Number of items in the sample with degradation (assume X=0)
n = Sample Size
p = Fraction of population size with degradation (use 10%)
N = Population size
z_α = Confidence parameter

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Sampling Bases

Considering a confidence parameter of 90%, z_α is equal to 1.645, according to Table 1.

DF	A	0.80	0.90	0.95	0.98	0.99	0.995	0.998	0.999
	P	0.20	0.10	0.05	0.02	0.01	0.005	0.002	0.001
1		3.078	6.314	12.706	31.820	63.657	127.321	318.309	636.619
10		1.372	1.812	2.228	2.764	3.169	3.581	4.144	4.587
20		1.325	1.725	2.086	2.528	2.845	3.153	3.552	3.850
30		1.310	1.697	2.042	2.457	2.750	3.030	3.385	3.646
100		1.290	1.660	1.984	2.364	2.626	2.871	3.174	3.391
150		1.287	1.655	1.976	2.351	2.609	2.849	3.145	3.357
500		1.283	1.648	1.965	2.334	2.586	2.820	3.107	3.310
∞		1.282	1.645	1.960	2.326	2.576	2.807	3.090	3.291

Table 1: Student's t-distribution

Following these premises the initial sample size is:

$$n = \frac{(24{,}35)N}{N + (24{,}35)}$$

Comparison Between Sample Sizes Methodologies

In comparison, The American Society of Mechanical Engineers-ASME [4] requires, for Class 3 components, that **10% shall be inspected**.

Comparing the sample size increase between ASME Code and EPRI methodologies is possible to conclude that for a small population the ASME's sample sizes is smaller, however as the population size increases the EPRI methodology grants a smaller sample size, **which is not greater than 25 items**, Figure 1 present its pattern.

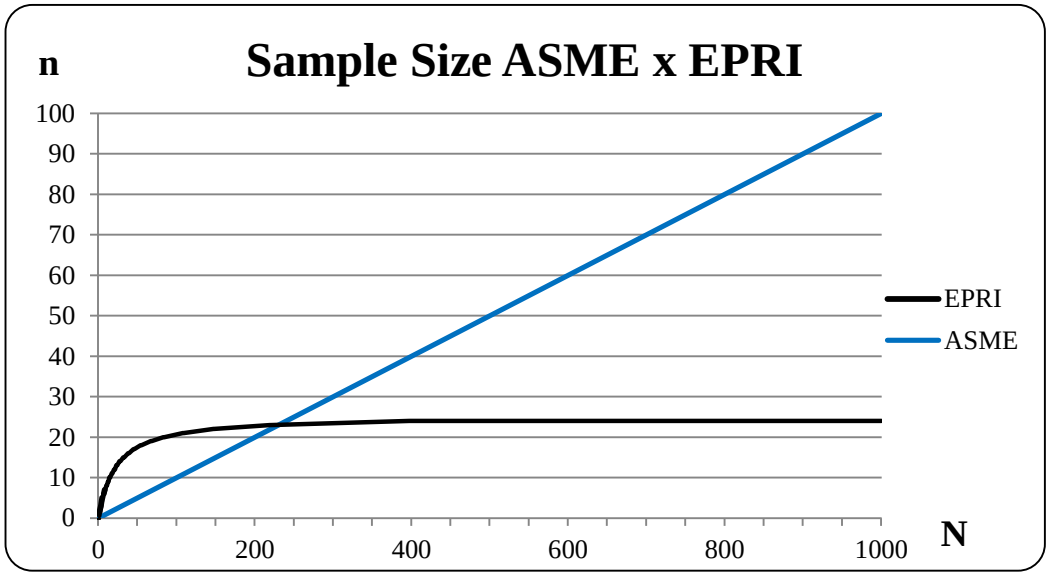

Figure 1 – Sample size comparison between ASME Code and EPRI methodologies.

Material + Environment + Aging Effect

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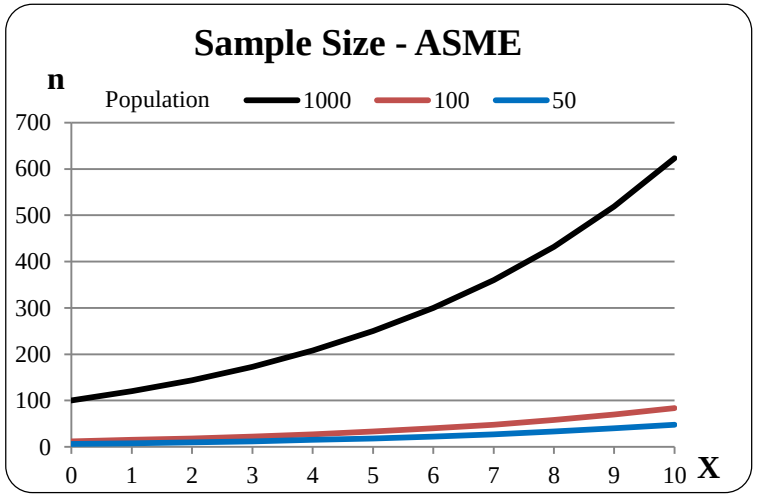
Comparison Between Sample Sizes Methodologies

a)



b)

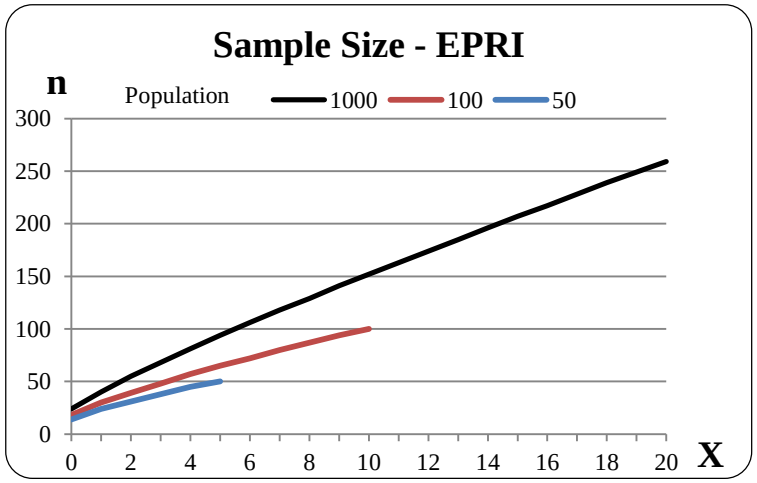


Figure 2 – Sample size (n) for items found with degradation (X). a) ASME, b) EPRI.

ASME BPVC SEC. XI

Initial Sample Size ➔ 10%
Each defect ➔ +20% of initial sample

EPRI

Recalcultate Δn for $X \neq 0$

$$\pm z_{\alpha} = \frac{X - np}{\sqrt{np(1-p)}\sqrt{\frac{N-n}{N-1}}}$$

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Conclusions

EPRI methodology is an alternative to define inspection program's sample size in cases that NUREG-1801 is too broad or not clearly defines it. Additionally it assures with a confidence level of 90% that the sample size defined represents the population behavior. A maximum sample of 25 components inspect trough sample defined by EPRI method assures that the population is represented, which is less then the number required for ASME Code for greater populations (N>200).

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References

[1] NUREG 1801 - Generic Aging Lessons Learned (GALL) Report, revision 2;

[2] EPRI–TR-107514 - Age-Related Degradation Inspection Method and Demonstration: In Behalf of Calvert Cliffs Nuclear Power Plant License Renewal Application;

[3] MEDCALC. Values of the t-distribuition (two-tailed). Avaiable in: <https://www.medcalc.org/manual/t-distribution.php> Accessed on: November 24, 2019;

[4] DO/NT LTO-003/2019 - Definindo Tamanho Amostral para os Programas de Gerenciamento de Envelhecimento;

[5] ASME Section XI – American Society of Mechanical Engineers – Boiler and Pressure Vessel Code, 2007 Addenda 2008.

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Acknowledgments

We would like to thank Eletrobras Termonuclear S.A. – ELETRONUCLEAR for giving us the opportunity and for providing us with a workspace and access to all the resources necessary to conduct this work.

QUESTIONS?

PERGUNTAS?

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