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Sent: Monday, June 02, 2014 7:51 PM
To: Gallagher, Carol
Cc: Stevens, Gary
Subject: NUREG 6909-rev 1 review - Docket ID NRC-2014-0023
Attachments: CFI-2014-007_LWR environment _indA-2014 06 02.doc

Dear all,

You will find some first general comments on NUREG 6909-rev 1
A longer time is needed to express more detailed remarks

With my best regards

Claude FAIDY

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CF Int

Structural Integrity Engineering

Title: Review of NUREG 6909 – Rev. 1 – **Docket ID: NRC-2014-0023**

"Effect of LWR Coolant Environments on the Fatigue Life of Reactor Materials"

Technical report reference : CFI-2014 – 007 Indice A

Author: Claude FAIDY **Date**: 2014-06-02 **Number of pages**: 4

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1. Introduction – General remarks

3 parts in the report:

- Mean and design air curves
- LWR environmental effects on Design air curve through Fen factors
- Consequences on ASME Code

Clear justification of environmental effects on fatigue in certain conditions: small specimen under membrane tension loads, R ratio -1, N_{25} criteria...

No test on industrial components close to real operation history and conditions: temperature and chemistry changes versus transient time...

The validity limits of the proposed rules seem to be larger than the tests conditions: like limited number of tests on Alloy 690 or on welds, or non satisfactory results over 10^4-10^5 cycles...

Some reduction factors use "conservative" unique value, mainly based on engineering judgement, like surface finished or temperature effects...

All the points are considered as independent each other: in fact it's not the case

Some definitions have to be added, like:

- LWR environment: in PWR for example the water chemistry has large variation in particular during shutdown (periode affected by thermal transients in some systems)

Figures are too small in many cases, with frequent large differences due to log-log plots

2. Air fatigue mean and design fatigue curves- Stainless Steels

2.1 Carbon and low alloy steels

- How to handle cladded components? And Heat Affected Zone areas?

2.2 Wrougth and cast austenitic steels and weld metal

- International agreement on mean curve up to 10^7 cycles, too limited values over
- Other proposals are available in different other countries for design curves: curve by limited group of materials, limited effect on scatter and no scale effect with the new criteria (3mm)
- Number of low carbon stainless steels (304L and 316L) and SS welds are limited in the data bank
- Are the tests on small weld specimen representative of industrial class 1 components? How grinding areas are considered?
- Justification of effects of specimen geometry (§ 3.2.2) is not largely discussed in connection with the new criteria (3mm): important point to reduce the scale reduction factor and transferability of results to components
- Justification of effects of strain hardening behavior (§ 3.2.5) is not sufficient: secondary hardening in some conditions can affected the crack initiation; include in factor 2 is not quantified

- Confirmation of large scatter of A value for different heats, that will leads to large conservative results for many cases (§ 3.2.7 and fig. 45)
- § 3.2.9 on welds: too limited number of data to conclude
- Surface finish effects: too small values of roughness considered, too limited number of data to conclude

2.3 Ni-Cr-Fe and welds

- § 3.3: 17 data points on 690 Alloys and 6 on Alloy 690 WM:
  - too small number,
  - to be improved in the future

3. Environmental effects on fatigue design rules- Stainless Steels

- All the reduction factors are considered independent, it's not accepted in all international approaches in particular a constant Ren independently of number of cycles is not justiried clearly
- Application of Fen on air design curve have to be largely discussed
- The final model seems to be too much conservative over 10^4 cycles

4. Code developments

4.1 Global consistency of the Codes

- 3mm maximum crack is not usable on thin components (less than 30mm thickness); 10% crack size in generally accepted by ASME Code; in the other hand a reduction of 10% is acceptable for level A where the margins are 1.5 versus collapse and 2.7 for instability; what's the consequence of 10% thining on level D criteria?
- It seems that no roughness requirements are specified in ASME Section III or attached specifications

4.2 Other points to be be considered

- Class 1 exemption rules have to be revised
- Crack like defect fatigue analysis has to be reviewed
- Other components are concerned: pumps and valves
- Cladded materials have to be considered
- Class 2 and in some limited cases class 3 components have to be considered
- Thin components, less than 30mm, have to be analyzed

4.3 Mechanism understanding and new data needs

- Effect of pre-hardening on fatigue life
- Effects of bi-axial loads
- New data for many materials: Alloy 690, 304L, 316L....

- Radiation effects and environmental fatigue tests: pre-hardening stainless steels
- Can we consider a correlation between fatigue resistance and stress-strain curves, effects of radiations or thermal ageing on some materials, or DSA? The argument is frequently used in the report

4.4 More realistic operation cases needed

- Temperature variation along the transient
- Effects of strong water chemistry changes

5. Conclusion

- Clear environmental effects is justified under certain conditions that are material and environment dependant
- In front of a so large number of parameters the existing proposal is probably extremely conservative and more data are required to progress
- In air a design curve can be derived with lower reduction factors than 12 and 2, 10 or 8 and 1.4 for 316L and 304L; all the Fen approach will be also affected
- Surface finish, mean stress and scale reduction factors need more justifications
- F_{en} applied to air design rules, instead of air mean curve, is not an optimum solution; some reduction factors can be different in air and under LWR environment
- Too much materials have to be considered in accordance with Section II and III of ASME Code that leads consequently to conservative predictions
- Application of F_{en} to vessel ASME existing rules is possible, not for piping and valves
- Many other details remarks need larger review time…