NUCLEAR CODE COMPARISON AND FUTURE NEEDS

Consistency from Design- Fabrication and Operation

Prepared by: Claude FAIDY
Consultant
claude.faidy@gmail.com
+33 6 1410 1119
AFCEN-ASME-EN
✓ A Code
✓ Existing comparisons
✓ Code Needs for future:
  ➢ Design and Fabrication
  ➢ Operation
  ➢ Dismantlement….
✓ Conclusions
A Nuclear Code

✓ It's not only a "set of books", it's also a large "community":

- A group of experienced people dedicated to Code development
- A group of Experts to assure High technical level, including pre-normative R&D
- A group of National and International Code users
- A group of National and International Safety Authorities in charge to review them
- A group of trainers of users

- A "quality assurance program" organization at each Code level / User level

Essential Tool for "knowledge transfer"
Recent Nuclear Code Comparison (2011)

- ASME III - RCCM - JSME – KEPIC – CSA – PNAEG
- Class 1 components: vessel, piping, pump and valves
- Topics:
  - Code organization and safety authority agreements
  - Design-Material-Fabrication- Examination requirements
  - Pressure Tests – Overpressure protection
- Differences: regulation / technical
- Comparison results are Code dependant
- For example for RCCM,
  on more than 600 requirements compared with ASME III:
  - 30%: identical or equivalent
  - 20%: different due to differences in scope
  - 50%: different due to technical differences: methods/data/criteria
<table>
<thead>
<tr>
<th>What kind of &quot;differences&quot; in Nuclear Design Codes?</th>
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<tr>
<td><strong>Regulatory requirements</strong></td>
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<tr>
<td>- Component classification</td>
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<td>- Design criteria</td>
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<td>- Material selection</td>
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<tr>
<td>- Fabrication qualifications</td>
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<td>- NDE Qualification / Performance</td>
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<td>- Quality Assurance</td>
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<td><strong>Standards</strong></td>
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<td>- National</td>
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<td>- Multi-industry:</td>
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<td>nuclear / non-nuclear</td>
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<td>- International</td>
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<td><strong>Administrative requirements</strong></td>
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<td>- Conformity assessment</td>
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<td>- Stamping</td>
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<td>- Professional Engineer</td>
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<td>- Inspectors</td>
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<td><strong>Scope differences</strong></td>
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<tr>
<td>- Prescription level</td>
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<td>- Type of Reactors</td>
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<td>- Possible use of not codified Materials</td>
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<td>- Jurisdiction</td>
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<td>- Maintenance and Ageing at Design level</td>
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<td>- Operation considerations at Design level</td>
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<tr>
<td>**Technical differences:</td>
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<tr>
<td>- SOA/Methods/Data/Criteria</td>
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✓ max of international standards (ISO) have to be considered

✓ For pressure equipment in particular, all these Codes & Standards have to lead to:
  - Similar margins in front of major failure modes, including internal/external hazards
  - Similar life evaluation in front of degradation mechanisms associated to operating conditions

Example for RCCM:
around 240 standards in RCC-M 2012 ➔ 170 are International ISO or EN
**Design/fabrication objectives for Pressure Equipment's**

- **minimize risk of "lost of integrity/ stability"** through margins in front of major failure modes in normal, upset, emergency and faulted conditions, including severe accidents for some plants (EPR…)
  - Safety classified components with associated graduation (class 1, 2, 3)
  - Non-safety class components (*dedicated Codes*)

- **minimize risk of "radioactive emission"** with associated graduation

- **analyze consequences of "accidental conditions and external/internal hazard"** in connection with Safety Analysis Report requirements

- **prepare "efficient maintenance activities"**: inspection, surveillance, repair, replacement

- **finally, guaranty "long term safety and economical efficiency"**:
  - maintenance cost/duration
  - radioprotection of workers
  - availability factor
Inspection program

- "defense in depth" to:
  - justify all the design margins all along the life
  - assure that operation conditions does not significantly "reduce design margins" through degradations (thinning, cracks, material property reduction…)

- define an inspection program based on:
  - Design analysis
  - Field experience
  - Potential degradation mechanisms
  - + Random inspection

Surveillance: all the major data to "understand and quantify ageing" effects

- Confirm design prediction and associated hypothesis
- Consider reduction of material properties: by radiation or thermal ageing
- Monitor "pertinent" loads and operating conditions (like transients, vibrations or water chemistry…)

Maintenance: repair / replacement of components

Manage radioprotection of workers, environment and public for all these previous activities
Specific requirement examples:

- **Radiation analysis**: material selection, surveillance on specimen, limited fluence…
- **Thermal ageing**:
  - low phosphorus in high temperature areas (> 320°C) for LAS
  - No molybdenum in cast stainless steel
- **Inconel 600**: limited operating temperature + specific heat treatment (resid. stresses)
- **Dissimilar Metal Welds**: Stainless steel or Alloy 52-152
- **Martensitic steels**: limited operating temperature
- **High toughness material**: limited sulfur content of LAS
- **Radioprotection**: low cobalt content material
- **High cycle thermal fatigue** in mixing cold/hot water areas: particular design
- **Stringent end of fabrication Non Destructive Examination** criteria, like hydrogen flakes in forged vessels (+ specific heat treatment case by case)
- **Use of International dimensional standards** for spare parts…
  ISO, EN, ASME-ANSI

Formal "Risk analysis" has to be submitted to Utility by Manufacturer at different design and fabrication stages, **as early as possible**
RSEM Operation requirements and Ageing management Program (AMP)

- List of degradation mechanisms
- List of safety components
- List of location by component
- Degradation rate
- Safety margin criteria (design analysis of failure modes)
- Cross table

**STEP 1**

- Diagnostic
- Mitigation
- Monitoring
- ISI
- Repairs
- Replacements

**STEP 2**

- Consequences
- Comparison with existing practices
- Anticipation developments

ASME, AFCEN, JSME, KEPIC ...

Codes and Standards:
mechanical, electrical, civil engineering ...
design and operation

July 7-10, 2014 - Prague
ASME-BNCS Workshop
AMP is a key issue for new plants:

- **Design life** has been continuously increased from 30 / 40 Years
- On-going in many countries to 60 Years through:
  - Periodic Safety Review
  - License renewal
- New designs for 60 Years
- Perhaps up to 80 Years in the future for some plants…

- Larger margins at design level
- More field experience included in new Codes
- More rules for degradation analysis
- More easy Inspection, Monitoring and Surveillance to justify Design Margins
- Easy repair / replacement of components

- All of that in accordance with low radiation level for worker, environment and public protection

**Important challenge for future Operation Codes Improvements**
New needs for Design-Construction and Operation Codes:

- Consider potential degradation due to operating conditions as early as possible in the Design process (including field exp.)
- Consider also: radioprotection and maintenance-inspection-surveillance in the Design process
- Integrate Ageing Management Program in Operation Codes: ISI and Surveillance, degradation analysis
- Find consistent safety factors with probabilistic risk analysis all along the life of the plant
Thanks for your Attention !!!

Open for questions and/or comments...