Challenges and opportunities in managing design basis knowledge

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Fundamental safety principle

• The licensee retains the prime responsibility for safety throughout the lifetime of facilities and activities, and this responsibility cannot be delegated.

• Other groups, such as designers, manufacturers and constructors, employers, contractors, and consignors and carriers, also have legal, professional or functional responsibilities with regard to safety.
The premise

To meet its responsibility for safety, a licensee is expected to:

• At first licensing, be responsible for the design of the plant

• Throughout life, to be aware of the complete design basis for the plant as it changes over 40 to 80 years, and to be responsible for ensuring that any design change maintains the safety of the plant.
The questions

• What is needed by a utility to satisfy these expectations?
  • Reliably
  • Cost effectively
  • Over a 40 to 80 year operating life
  • To the satisfaction of regulators

• Are we satisfying these expectations now?
  • INSAG 19 was written 10 years ago
  • Are failures in DBKM a contributing factor in accidents?
  • Gen 3 lifetimes make it more difficult

• Can all licensees meet these expectations?
  • There is a substantial cost involved
Challenges are opportunities

• To maintain a large body of complex engineering data accurately over a 40 to 80 year period is a major challenge
• We have had difficulties with this over the last 40 years
• Gen 3 plants are expected to have a failure rate one tenth of that achieved with Gen 2- a major challenge
• We – Designers, operators, suppliers, regulators- need to look critically at our institutional processes
• The institutional decisions we make now set the scene for the life cycle for Generation 3 ........ 60 to 80 years
• And perhaps for the remaining lifetimes of Gen 2
Issues at first licensing

• There is no generally accepted definition of “the design basis” –
• Or “the complete design basis”
Design Basis- 10 CFR 50.2:

“That information which identifies the specific functions to be performed by a structure, system, or component of a facility, and the specific values or ranges of values chosen for controlling parameters as reference bounds for design. These values may be (1) restraints derived from generally accepted “state of the art” practices for achieving functional goals, or (2) requirements deriving from analyses (based on calculation and/or experiment) of the effects of a postulated accident for which a structure, system or component must meet its functional goals.”
Design Basis- INSAG 19:

• A detailed understanding of why the design is as it is.
• The experimental and research knowledge on which the design is based.
• The design inputs such as basic functional requirements, performance requirements, safety goals and safety principles, applicable codes, standards and regulatory requirements, design conditions, loads such as seismic loads, interface requirements, etc.
• The design outputs such as specifications, design limits, operating limits, safety limits, failure or fitness for service criteria.
Design Basis- INSAG 19:

• A detailed knowledge of the design calculations which demonstrate the adequacy of the design and the ability to reproduce the design calculations if needed.

• An understanding of the inspections, analysis, testing, computer code validation and acceptance criteria used by participating design organizations to verify that the design output meets the design requirements.

• The assumptions made in all the steps above, including assumptions related to operating modes or procedures, expected life history such as changes in fluence, expected transients, etc.

• The implications of operating experience on the design.
design basis: The range of conditions and events taken explicitly into account in the design of a facility, according to established criteria, such that the facility can withstand them without exceeding authorized limits by the planned operation of safety systems (IAEA Safety Glossary)

Used as an adjective, applied to specific categories of conditions or events to mean ‘included in the design basis’; as, for example, in design basis accident, design basis external events and design basis earthquake (IAEA Safety Glossary)

Conditions that are taken into account when designing a facility or product (Law Dictionary)
Issues at first licensing

• There is no generally accepted definition of “the complete design basis”
• The amount of information is huge
• Design basis information (INSAG) is likely held by several organisations
Organisations holding DBK at first licensing

• The research organisations who have developed material knowledge, accident modelling etc ....

• The original plant designer
  • Of the nuclear steam supply
  • Of supporting systems ( electrical distribution, service water, cooling water....)
  • Steam generators, main coolant pumps.......  

• The architect engineer

• Component suppliers

The list is a function of utility’s role and contracts
  - architect engineer vs turnkey
Issues at first licensing

• There is no generally accepted definition of “the complete design basis”
• The amount of information is huge
• Design basis information is likely held by several organisations
• Experienced licensees will become familiar with most of the design basis at first licensing
• New licensees likely will not be familiar with the complete design basis at first licensing
• There is no general agreement on the extent of design basis information to be transferred at first licensing
• All licensees rely to some degree on the design basis knowledge held by original designers
Issues during Operation

- The design basis changes continually over life
- Over 60 years or more the design changes are substantial—particularly in I&C
- The amount of design basis information increases with time—significantly
- There are many contributors to the changes
Contributions to changes in DBK

- Obsolescence
- New knowledge – of materials, environmental impacts etc
- Better understanding of accident progressions
- Periodic safety reviews
- OPEX from the plant
- OPEX from other plants
- Lessons learned from accidents
- New regulatory standards
- Upgrades
- Refurbishments
Issues during Operation

- The design basis changes continually over life
- Over 60 years or more the design changes are substantial—particularly in I&C
- The amount of design basis information increases with time—significantly
- There are many contributors to the changes
- At the end of a new build program, licensees tend to reduce their design staff
- Over time, many licensees will not maintain a complete knowledge of the design basis in house
- To meet their responsibilities, all licensees require continued access to the design basis knowledge held by others
Issues during Operation

• No general agreement on the minimum level of in house knowledge to meet licensee’s responsibility
• Licensees’ access to design basis knowledge held by designers/suppliers is very varied
• All the organisations that hold design basis knowledge need to be involved in its management through the life of a fleet
• Designers and suppliers need feedback from operations to manage their design basis information
• Long term relationships between operators and designers/suppliers need to be clarified
Economic issues

• DBK must reflect the actual state of the plant at all times – configuration management is an essential element

• The amount of information to be managed is very large and increasing

• All licensees are expected to be aware of, and incorporate OPEX from other plants, particularly from like plants

• Managing DBK is expensive

• The cost of not managing DBK is likely to be much greater

• For smaller licensees the overhead costs can be prohibitive

• Utilities operating the same reactor design should be able to work together to substantially reduce costs
Economic issues

• Large utilities with large fleets obtain economies of scale in DBK management
• Large utilities can use sophisticated data management tools
• Smaller utilities with small fleets need the economies of working in a fleet environment to access this
• Examples:
  • common formats for exchanging OPEX data, component failure modes and rates
  • Sharing of expertise
  • Data handling systems that are compatible
  • Design changes to meet new standards (Fukushima)
• Agreement needed with WANO- confidentiality issues
Design Authority: 3 definitions

1) A specific senior manager within a Utility who is responsible for approving all design changes to a plant. She
   • Is responsible for ensuring design basis knowledge is available to the utility
   • May rely on recommendations from organisations that have design basis knowledge
   • Is “responsible customer”- ensures Utility has sufficient “in house “ competence to assess contractors’ proposals

2) The organisation within the Utility that carries out this function. The size of such an organisation can vary from about 100 (or less?) to 5000

3) An external organisation with full technical competence in a specific area assigned with this responsibility
Responsible Designer

An organisation that:

• Has been assigned the responsibility to supply design basis knowledge in specific technical areas
• Ensures its Design Basis Knowledge is available to a utility whenever required
• Is responsible for maintaining its design basis knowledge
• Will need feedback from OPEX and elsewhere to maintain its design basis
• Could provide the role to all utilities with the same design
• Is likely the original designer or its successor organisation
• But may not be
• Much confusion over this term
Barriers to the management of DBK

• There appears to be some lack of appreciation of the commercial and safety implications of a loss of DBK
DBK and Utility Directors

• Utility Directors have to see DBK as an asset
• Does loss of DBK affect their bottom line?
• Is it a risk to be managed?
• If yes, they will manage it:
  • Assign resources
  • Put in management processes
  • Require metrics to show process followed
  • Follow up
• If no, this won’t happen
• Currently, the evidence for high risk is not clear to many Directors
• No international studies of the effects of not managing DBK
Barriers to the management of DBK

- There appears to be a lack of appreciation of the commercial and safety implications of a loss of DBK
- No international studies of the effects of not managing DBK
- Competitive bidding on a job by job basis makes it very difficult to manage DBK for operator and original designer
- There is no agreement on how an operator can assign specific responsibilities to the original designer/supplier
- Many operators are reluctant to enter into long term relationships with design/supplier organisations
- Maintenance of DBK within a design organisation over a long period requires long term agreements that are fair to both sides
Barriers to the management of DBK

- Regulators are very reluctant to come to any agreement on the relative responsibilities of operators and designers/suppliers
- “we only licence the operator –he is wholly responsible. We don’t licence the Designer”
- The “responsible designer” role should to be recognised by regulators if they are to be responsible for maintain DBK
- If “design certification” and “standardized designs” are to have real meaning, this is essential
- Regulators recognise manufacturers – but not designers....
Institutional fixes

• The definition and extent of design basis knowledge is understood and agreed on
• The roles of all the players involved in the long term management of design basis knowledge are recognised
• DBKM is recognised to start for all the agreed partners when the original contract is signed
• The term “Design Authority” is understood and accepted
• The term “Responsible Designer” is understood and accepted
• Utilities with similar plants work together in managing DBK, to reduce costs and improve the use of OPEX
• OPEX is shared with responsible designers
Different DBK arrangements

- New utility
- Medium utility
- Large utility
- Small utility

Vendor
Other issues

• Concentration of knowledge - good or bad?
• Tacit knowledge - fixable?
• Deficiencies in fleet management - Fukushima
• Leadership: essential - but not sufficient
• Maintenance of individual expertise: essential but not sufficient
• All these need modern DBKM processes to support them plus exercising knowledge through using it
• DBKM in regulators - good or bad?
Conclusions

• DBKM is a very large task in terms of
  • the amount and variety of data,
  • the variety of the form of the data
  • The number of places in which it is held
  • The tools needed to handle it
• Worldwide, it is not handled well
• There are some fundamental barriers which must be addressed if improvements are to be made
• The IAEA can provide a forum to address these barriers
• A Tecdoc may help
• Other fora for utilities to develop workable systems are essential
• WANO, INPO and the new safety construct initiative should discuss these issues
thank you