Topics

- Requirements, Guidelines
- Evaluation Criteria
- Comparison of 2 ICF
  ICF and MCF
- Safety and Environment
- Others

Requirements, Guidelines

Set A: Common (to both teams)
Set B: Target (classification issue)
Set C: Design Team Specific

Set A: Common Requirements

- Common to both (two?) teams
- To be specified by DOE/Advisory Committee
- Objective
  - Provide consistency in comparison between the 2 ICF Driver Designs, between ICF and MCF, and between the two teams conclusions

- Should be limited to top level parameters (e.g. fusion power) and design guidelines
  - Avoid specifying detailed parameters and stating guidelines that are best resolved through tradeoffs (e.g. tradeoffs between safety and environment make it unwise to provide simplistic "minimum activation" goal)

- Procedure to establish requirements
  1. Immediately after announcing the winner, (assuming 2), each team will prepare a list of suggested parameters and guidelines.

  2. Forward the list to DOE/DOE Advisory Committee prior to the official start date.

3. DOE/DOE Advisory Committee decides on and issues a set of preliminary requirements/guidelines on or before the start of the project.

4. Some modifications/additions/deletions are considered during the first month

5. Final requirements/guidelines discussed in a DOE sponsored workshop for both teams during the 5th week of the study (workshop can have other topics such as "Target Assumptions"

Examples of "Common" Requirements/Guidelines

1. Purpose of plant: Only electric power production
2. Fusion Power (e.g. 2500 MW)
   Alternatively, specify electric power (e.g. 1000 MW_e)
3. Tenth commercial reactor power plant
4. Start year of operation (e.g. 2030)
5. Private utility ownership
6. Single generating unit at the site
7. Plant lifetime
   For engineering design (e.g. 40 years)
   For economic analysis (e.g. 30 years)
8. DT Fuel cycle
9. Satisfy tritium self sufficiency conditions
10. General site assumptions
11. Overall plant availability? (e.g. 75%)
12. "Pure" fusion reactor (no fissionable materials)
13. etc.

Set B. Target Guidelines/Assumptions

- One of the most difficult areas for the design teams to work with is information on the target (design specifications, materials, performance, etc.)

- Information on the target are crucial for:
  - Reactor performance, design (e.g. pellet gain, radiation spectra, neutron multiplication)
  - Economics evaluation
  - Certain areas of safety and enviornment (Example: Easily activated heavy materials in the target)

- Target design information/assumptions (e.g. range of gain, radiation spectra, materials, cost, etc.) Must be provided by DOE/DOE Advisory Committee to both teams
  - Clever ways must be found to provide the information necessary for unclassified design (Example, if materials can not be specified, a plot of the radioactivity level in Curies as a function of gain can be considered)

- It will also be necessary for the design teams to obtain information on "Physics and Engineering Extrapolations" for assumed target conditions. Comparison of ICF and MCF will involve attributes for 1) difficulty/probability of success, 2) cost and 3) time for required R&D.

"Initial Thoughts" on Evaluation Methodology

- Establish 5 major areas of evaluation
  1. Physics Feasibility
  2. Engineering Feasibility
  3. Economics
  4. Safety and Environment
  5. Research and Development (cost and time)
- Under each area establish subcategories (attributes). Each subcategory would have a weighting value
- The comparison process will involve estimating a value for each attribute. The weighted sum of attributes for each evaluation area represents a SCORE for this area.
- No mixing of the 5 evaluation areas is recommended. Only a panel of very knowledgeable experts should interpret the results given the scores in each of the 5 evaluation areas.

Evaluation Criteria/Methodology

Developing an Evaluation Methodology is an important part of this project.

Purpose: To permit quantitative comparison of the 2 ICF Designs and of ICF/MCF

Common or Separate?

Should each design team develop its own Evaluation Criteria? Or, should there be one common set for both teams?

Separate:

1. Provide truly two independent evaluations
2. Would ensure uncovering more areas of differences
3. Would make common conclusions stronger
4. More practical (interaction between two teams may not be efficient.)

Common:

1. Assures uniformity between the two teams
2. Ensures that differences in conclusions between the two teams are not merely due to differences in evaluation criteria

Procedure to Establishing Evaluation Methodology

- An Evaluation Methodology Group (EMG) will be established from the beginning of the project

- EMG will consist of 5 or more persons with broad experience covering all critical areas such as Physics, Engineering, Economics, and Safety/Environment

- Schedule
  - First 3 months: Intensive effort to develop methodology
  - Next 9 months: Slower pace to refine and finalize criteria based on interaction with the design evaluation and issue identification
  - Last 6 months: EMG serves as the "core group" for performing the comparison for the 2 ICF designs and ICF/MCF. Group will be augmented by other key technical personnel from the design team.

Examples of Attributes

Economics

Cost of energy
(includes capital cost, operating cost, replacement cost, availability and assumptions on interest rate and construction period)

Engineering Feasibility   Weight

- Engineering Complexity and Fabrication
  - Target
  - Driver
  - Cavity
  - etc.
- Maintenance and Repair
- Accommodation of Power Variation
- etc.

"Initial Thoughts" on Comparison

Compare 1) 2 ICF (Driver) Designs
2) 2 ICF Designs to MCF

- Use Evaluation Methodology discussed earlier

- For MCF designs consider 2 representative designs
  - ARIES
  - STARFIRE

  The two designs represent well the range of options considered for MCF (tokamaks). Other designs can be considered when needed for special cases.

- Whenever possible, attempt to provide consistent comparison on the subsystem levels

- In areas such as Engineering Feasibility and Safety and Environment, evaluators must strive to identify the generic differences rather than those caused by only designers convenience/opinion

  Example: High activation material used in one design while low activation material is used in another evaluation, should address whether there are "generic" or "opinion" choices.

Safety and Environmental Impact

- Safety and Environmental impact will receive high priority in this project

  1. Design
     - During the design phase, tradeoffs for material and design option selection will include in a major way, Safety and Environmental impact
     - There will also be specific design guidelines related to safety and environment

       e.g.
       - Normal Tritium loss rate via steam generator must be below (100 Ci/day)
       - No material combination resulting in a large rate of energy release is allowed

  2. Analysis

     Extensive analysis is planned for
     - Source term characterization
     - Accidents and Fault Tolerance
     - Nonaccident concerns

  3. Evaluation Criteria

     Safety and Environmental impact are part of the major criteria in the Evaluation Methodology for comparison of ICF's and MCF

- Results of previous evaluations, assessments and design studies will be utilized to the fullest extent.

  e.g. EASICOM, EC Report, Low Activation Panel, MFAC Panel, Material Recycle/Waste Management (ANL/163), MCF Designs, ICF Designs.

Safety/Environment Analysis

1. Source Term Characterization
   (Tritium, neutron activation products, chemical toxicity, etc.)
   - Target
   - Cavity (structure, multiplier, coolant, etc.)
   - Driver
   - etc.

2. Accidents and Fault Tolerance
   (Consequence and likelihood of occurrence)
   Effort will focus on identifying and analyzing major areas (e.g. beam missing target, cooling transients, materials and subsystem interactions, wall protection (lithium?) interactions or failure)

3. Nonaccidents Concern
   - Normal Radioactive Effluents
   - Occupational Exposure
   - Waste Management
   - etc.

Safety/Environment Tradeoffs

- There are often conflicts between safety and environmental impact

Examples

- Materials with low long-term radioactivity often have high decay heat (may make it difficult to satisfy inherent safety goals)

- Some structural materials with low long-term radioactivity may have a higher failure rate or less desirable safety features (Examples: SiC, Li/V)

- Some design features can improve one area but adversely affect another area
  Example: Lithium fall for wall protection
    - reduces structure activation
    - introduces hazards of lithium fire

- Such conflicts will be addressed as part of the tradeoffs for material and design option selection in this study.

Safety and Environmental Impact
Team Capabilities

Personnel: M. Abdou, S. Ostrow, N. Ghoniem, S. Sharafat, R. Raffray, M. Youssef, Others...

Organizations

Ebasco: Extensive experience on behavior, safe handling and design of equipment and systems related to tritium

CFFTP: Experience with tritium handling, fusion commercial and (CIT, ITER) designs

UCLA:

- Very extensive experience in safety and environmental analysis for fusion reactors (ARIES, BCSS, fusion material studies, FINESSE, fusion nuclear technology evaluation, waste management/material recycling study)

- On-going experimental and analysis programs for radioactivity and decay heat on actual materials in the fusion environment (Unique 3-D codes and libraries with time-dependent analysis capabilities)

- On-going methods and code development for transient analysis
e.g. Tritium transport and release under transient conditions
Thermal Control and Transient Analysis

Others: The team intends to interact with other experts and organizations as needed

General Remarks

- The main objectives of the study are

    - identify key technical issues for the two ICF designs
    - compare the two ICF designs
    - compare the two ICF designs to MCF

  Key areas of comparison are physics and engineering feasibility, economics, safety and environmental impact and R&D requirements

- The study will be limited in resources. The objectives will be best met by:

    - Focusing on Critical Issues, subsystems and areas where there are substantial differences between ICF and MCF
      e.g. emphasize "nuclear island" (target, cavity, driver)
    - Spending less effort and using expert judgement in areas that do not have key issues and do not affect the comparison. For example, in some parts of balance-of-plant.

- Results from previous ICF and MCF studies will be fully utilized.